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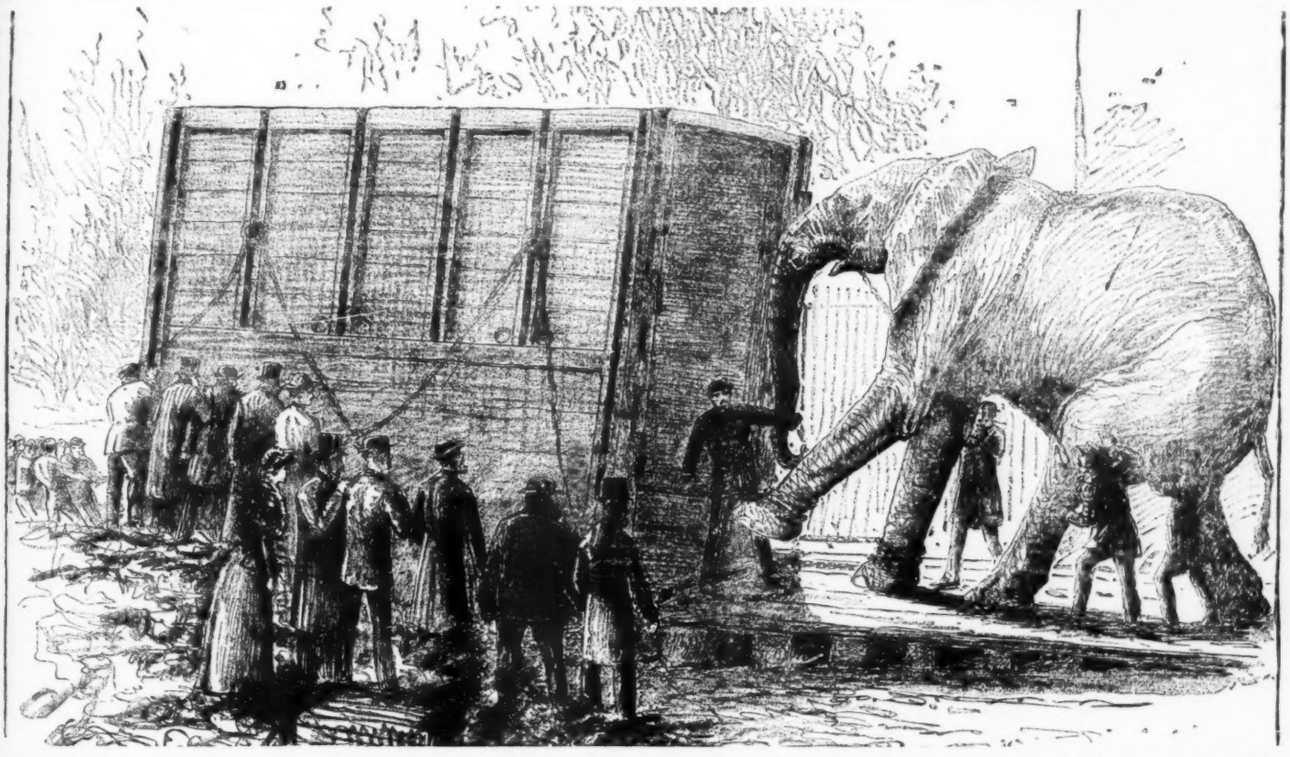
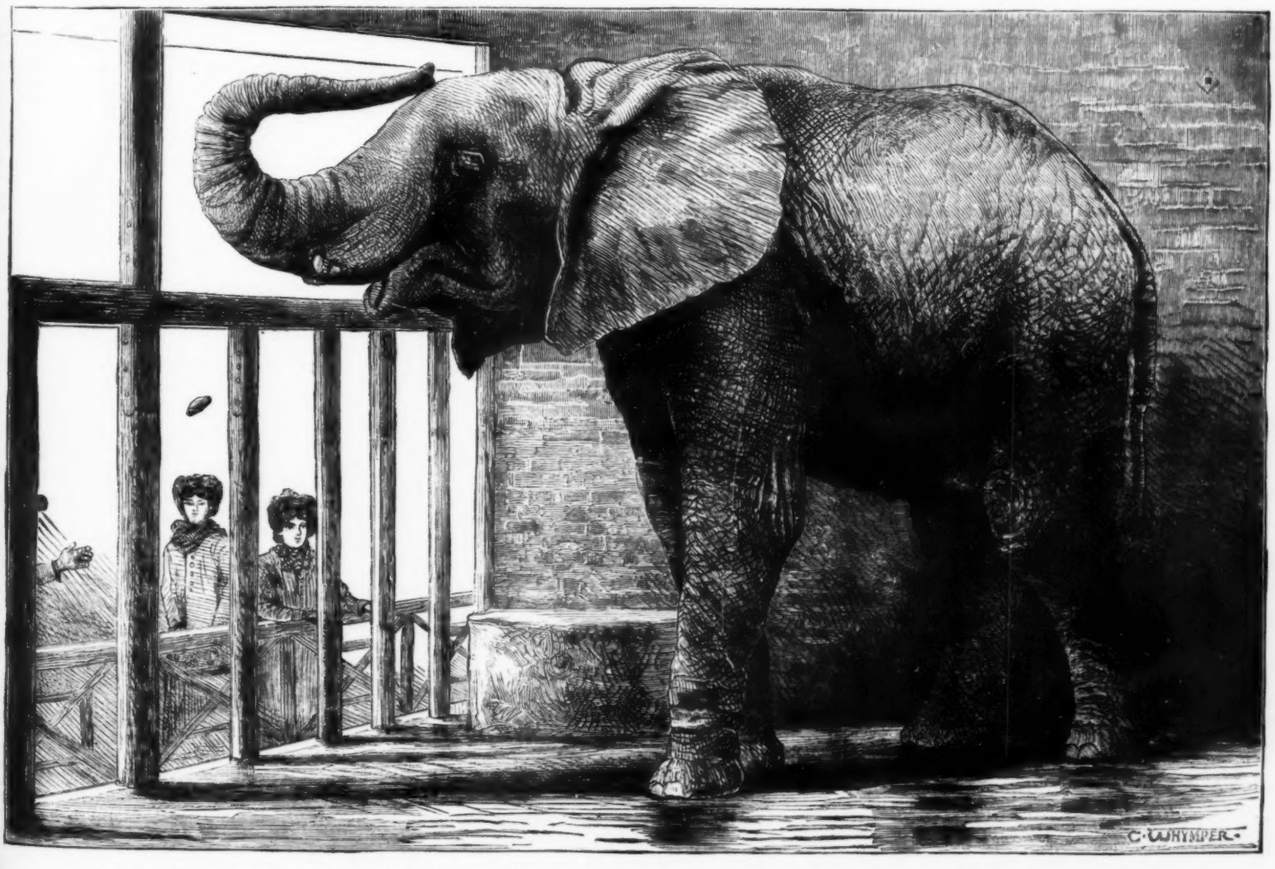


ATTEMPT TO REMOVE JUMBO, THE GREAT ELEPHANT, FROM THE ZOOLOGICAL GARDENS, LONDON.



JUMBO, THE GREAT AFRICAN ELEPHANT, FROM THE ZOOLOGICAL GARDENS, LONDON.

A NOTABLE ELEPHANT.

SEVENTEEN years ago the London Zoological Society procured from Paris a baby elephant, which, in process of time, grew to be a creature of immense size, and for several years the beast has been used in the Zoological Gardens to carry about the loads of children and visitors that were always clamoring for an elephant ride. The great animal, named Jumbo, as he increased in size and years developed also some bad traits of character, becoming so vicious that the directors finally decided to get rid of him So Mr. P. T. Barnum, of this country, lately became the purchaser for $10,000. But to get him on shipboard and carry him to New York was no slight job, as the following description from the *Illustrated London News* and the London *Graphic* will show. The *News* says of Jumbo: Born in Africa, he is a Londoner by youthful education and friendly associations. He has grown, both in reason and in stature, under the care of kind Mr. Bartlett, the superintendent. Seventeen years ago, when he arrived from Paris, he was little above four feet high; now he stands upwards of eleven feet. He is the tallest of the African elephants in captivity,and nearly two feet taller than any on view in the United States of America, where tall things are so much admired. It therefore entered into the mind of Mr. Phineas T. Barnum, the famous American showman, to buy Jumbo, and the Zoological Society of London have sold Jumbo for £2,000. Mr. Barnum has been the possessor of twenty elephants; he imported thirteen at once from Ceylon, direct to New York, of which eleven are still living. He has sent hither Mr. William Newman, familiarly called "Elephant Bill," to fetch the big African, all risks of transport being taken by Mr. Barnum. A passage was engaged for Jumbo on board the steamship Persian Monarch, in the docks at Millwall; but Jumbo's consent to emigrate had not been asked. The appointed hour for his departure from the gardens came last Saturday afternoon, Feb. 18. Our illustrations, with the aid of some descriptive particulars borrowed from a report in the *Daily Telegraph*, show the arrangements made for this purpose and the failure to effect his removal. Just outside the elephant-house, an immense box, like a packing case made of thick planks, clamped and screwed on a strong framework of beams, was mounted on a low trolly. This was in a sunken spot of ground, so that the floor of the box should not be much above the level of the earth, from which Jumbo was to be marched along a gently sloping platform. To facilitate the draught of the heavily-laden trolly out of the deep ground, broad, smooth iron grooves had been laid down along the track on which the thick, squat wheels were to travel. Openings in the sides and ends of the box would allow the attendants on Jumbo to gain access to the moving cell in which he was to make a trying voyage. But Jumbo did not fancy the vehicle prepared for him. It was in charge of the persons who had been sent from the United States, with the help of Scott, the keeper of elephants at the Zoological Society's Gardens, in whom of all the men about the place Jumbo reposed great confidence. Mr. Bartlett and his staff had entirely relinquished all command or responsibility concerning Jumbo. Something like the late Mr. Rarey's method of convincing a horse that he is powerless to act against his master's will was pursued toward this elephant. Using one of the strong chains as a strap, the American, with the assistance of Scott, fastened it round the leg, just under the joint that tallies with the knee of most quadrupeds, though this, in the elephant, is no higher above the fore-foot than the wrist-joint in a human being is above the hand. In point of fact, the chain may be said to have encircled the upper part of the foot. Jumbo submitted quietly enough to the operation, and even surveyed the motions of his new acquaintance with some appearance of curiosity. When, however, Scott had wound the other end of the chain round one of the stout, post-like rails of the barrier in front of Jumbo's compartment, so that the beast found himself unable to move except within a narrow space, he was evidently disconcerted. Still, he allowed a second chain to be girded round his other foot; and, with rather more allowance of play for the limb, by a lengthening of the iron cable, he presently felt that both legs were captive. This troubled him in no small degree, and he set about trying to snap the chain by powerful jerks, now and then feeling the coil round the bars with his sensitive proboscis, and lifting the chain to let it fall heavily on the stones. He was now much dejected, and showed for the first time unmistakable signs of fear. A much longer and equally massive chain was thrown over his back and fastened beneath his enormous body. Then a similar chain was placed round his forehead, just above the broad base of his trunk, where the stumps of tusks that have been fretfully rubbed and worn away project outwardly. A connecting chain, which passed between his fore-legs, formed a sort of martingale; and as soon as Jumbo was conscious of its restraining effect he gave passionate vent to his alarm and anger. His loud trumpetings and fierce assaults upon his iron bonds told a tale of something wrong to elephants right and left of him. Solitary prisoners as they were, each in separate confinement, they tried desperately to get a sight at what was happening close to them,and joined chorus with poor Jumbo in bellowings of dismay. The female elephant, Alice, Jumbo's "little wife," as she is called, was most painfully agitated, and cried piteously in the stall next her lord's. But no rescue was brought, and Jumbo roared the louder when he heard the sympathetic moans of his wife and friends. By degrees the noise subsided, and Jumbo, tranquilized by exhaustion, became comparatively calm. Scott, taking his seat on the edge of the stone tank, and facing the now pacified animal, offered him biscuits, which poor Jumbo took with his pliant trunk, and conveyed slowly, one by one, to his cavern of a mouth, eying his friend the keeper reproachfully as, from time to time, he shook and clanked the heavy fetters. Not till six o'clock was it judged prudent to loosen these chains and to lead Jumbo to his box upon wheels. He walked quietly enough to the entrance, only trying with a cautious touch of his foot the firm wooden approach. But, having reached the opening, he halted, and could not be induced to move a step further. After several trials, the attendants gave up the business as impracticable, for the Saturday night.

On Sunday morning, at an early hour, Jumbo was again led out, with the intention of making him walk to the docks at Millwall, instead of being carried. He was still in chains, and seemed quiet enough as he marched toward the wooden gate opposite the parrot-house. Before emerging on the road Jumbo tried the ground, which differed in appearance from the accustomed gravel path inside the grounds; and not being satisfied as to its security, he refused to proceed. Efforts were made to drive him out, and the animal showed much distress; he moaned sadly, and appealed to his keeper, embracing the man with his trunk, and actually kneeling before him.

Jumbo's cries were soon heard in the elephant-house, where his female consort was again seized with alarm and grief, so that very note of sorrow from the kneeling elephant in the road had its response within the gardens. At the sound of Alice's increasing lamentations, Jumbo became almost frantic, and flung himself down on his side. It was at length resolved to give up the attempt for that day.

On Sunday afternoon, when the gardens were opened, as usual, to Fellows of the Zoological Society with their friends, and to others having private tickets given them by the Fellows, Jumbo was brought out, as he always is on public days, and behaved with his characteristic gentleness. He has since been a greater favorite than ever with all classes of visitors to the gardens, taking food out of their hands, and carrying loads of children on his back; but, during some part of the day, or rather at night, the chains have been put upon him, while confined in his stall, by order of "Elephant Bill," with a view to accustom him to their weight and noise. The box or cage upon wheels has undergone some modifications in detail, and will be narrowed, so as to afford support on each flank to the huge beast, if he be indeed doomed to exile from the country which has been so long his home. This box will now be daily placed in front of his stable door, the low wheels being sunk in the ground, and both ends of the box being left open, so that, passing out through it daily, he may become accustomed to its appearance.

An attempt will be made in a fortnight to ship him by the next steamer of the "Monarch" Line; one of this line being chosen because they have very long and wide hatchways and great height between decks.

In a subsequent number the *News* says:

The large male African elephant at the Zoological Society's Gardens in Regent's Park has gained weekly and daily in popularity since his refusal to go to the docks and embark for America, in accordance with the bargain for his sale to Mr. P. T. Barnum and others at New York. Never were such crowds of visitors to the gardens at this early period of the season, all thronging to the elephant-house, or watching the huge animal in his customary promenade in another part of the grounds, and offering him an unusual quantity and variety of eatable dainties, while the eagerness of children and young girls to ride on his back is beyond all precedent. The illustration of this ordinary performance engraved on our front page is from a photograph taken by Messrs. Briggs & Son, of the St. John's Wood School of Photography, 40 High Street, St. John's Wood. The number of people at the gardens last Monday was twenty-four thousand; On Saturday, nearly seven thousand. There were 43,658 admissions last week.

The newly constructed box, or van, in which it is hoped Jumbo will soon be removed to the docks at Millwall, if he can once be confined in it, is a massive vehicle, of the dimensions necessary for an elephant that stands eleven feet high, and that weighs between five and six tons. The frame of the van is composed of solid balks, mortised, bolted, and over all heavily clamped with iron. The flooring is of three-inch planks, and the sides and roof are lined with inch-and-a-half deal. The van is of such strength as is calculated to resist twice or thrice the force that even this powerful brute could possibly bring to bear against it. Important changes have been made in its formation, and still more in the trolly in which it is fixed; so that, instead of being four feet above the ground, the floor of the van will only be raised about eight inches. It is, for the present, sunk to the level of the ground, which has been dug out for the purpose, and the floor covered with gravel. Axles of enormous strength have been fitted with special boxes and wheels, the width of the lower structure being governed by that of the gateway through which the van is to leave the gardens. In the meantime, it is arranged as a kind of trap, with both ends left open, and being placed opposite the door of Jumbo's house, on the way to his exercise-ground and bathing-pool, he is becoming accustomed to walk through it, which he did for the first time on Saturday. The doors of the van will be suddenly closed upon him at some convenient opportunity, when he is in chains, and the chains will be attached to the strong rings fixed inside the van, after which, it is thought, he cannot make any further resistance. The weight of elephant and van together will be about ten tons, which must be drawn by horses six miles through the streets, from Camden Town to Millwall. Having reached the docks, a steam crane will be employed to hoist up Jumbo in his box, and to put him into the ship which is to carry him to New York.

In the Chancery Division of the High Court of Justice last week, Mr. Justice Chitty refused to grant an injunction restraining the council of the Zoological Society from selling this elephant and Mr. Barnum's agent from removing him to America. The injunction was applied for by Mr. Berkeley Hill, one of the Fellows of the society, whose counsel argued that it was not legally in the power of the council so to dispose of animals valuable for the study of natural history. Dr. P. L. Sclater, the secretary, and Mr. A. B. Bartlett, superintendent of the gardens, were called as witnesses to state that it would be inconvenient, and perhaps dangerous, to keep Jumbo there till the age when he would become liable to certain fits of rage. The application was, therefore, dismissed by the court.

The London *Graphic* says: There is great lamentation in juvenile circles just now, for Jumbo, the large African elephant at the Zoological Gardens, has been sold to the great American showman, Barnum, who intends to take him on a starring tour through the United States. It will be difficult to understand the Zoo without Jumbo and his cargo of merry children, ranging from the tiny trot of two, more than half afraid of the unwieldy monster, and only quieted by the keeper, who seemed to be as skillful in managing children as in controlling his huge steed, to the bold youngster of six, with whom Jumbo was a familiar friend, or the sedate damsel of thirteen, who mounts more for the sake of old times than for the actual enjoyment of the ride. Jumbo was a universal favorite, and as gentle with children as the best trained poodle dog, taking the proffered biscuit or lump of sugar with an almost incredible delicacy of touch, so that the most nervous child, having once overcome his alarm, never hesitated to hand a morsel to the waving trunk a second time. Jumbo, however, when in his house displayed a very uncertain temper at times, and this has induced the society to part with him. Mr. P. L. Sclater, the secretary, in a letter to the *Times*, states that for some time past Jumbo has been a source of anxiety, as elephants after a certain age are liable to periodical fits of excitement. Under such circumstances the risks of an outbreak on the part of so huge and powerful an animal in the much frequented gardens of the society is one which should be not lightly run. In Messrs. Barnum's establishment, where twenty elephants are kept, an animal can be withdrawn and placed in seclusion, for which there is no adequate provision in the Zoological Gardens. The price offered was £2,000, and Mr. Barnum agreed to take all risks of removal. Mr. Barnum, however, had reckoned without asking Jumbo, who, up to the time we are writing, has firmly declined to consent to the arrangement, and has resisted all the blandishments of Scott, his favorite keeper, who has been told off to accompany him throughout the voyage. Saturday last had been fixed for his removal to the docks, and chains having been passed round his legs and body, Jumbo soon felt that something was wrong, and gave vent to loud trumpetings of dismay and anger, while vigorously trying to free himself. The other elephants bearing his cries joined in chorus, and the female, Alice, or, as she is called, Jumbo's "little wife," was almost beside herself with anxiety. By and by, however, Jumbo calmed down, and Scott and the well known American expert, Mr. William Newman, otherwise known as "Elephant Bill," who had been sent to superintend the removal, attempted to induce him to enter the box on wheels, in which he was to be conveyed to the dock. This, however, he absolutely refused to do, and finally he was left quiet for the night. Next day it was decided to attempt to lead him through the streets. Jumbo walked calmly enough to the entrance, but then, feeling a different soil under his feet, became once more alarmed, and refused to proceed further. "Then ensued," states a writer in the *Daily Telegraph*, "one of the most pathetic scenes in which a dumb animal was ever the chief actor. The poor brute moaned sadly, and appealed in all but human words to his keeper, embracing the man with his trunk, and actually kneeling before him. Jumbo's cries were soon heard by his 'little wife,' who quickly responded with loud trumpetings, at the sound of which Jumbo became frantic, and flung himself down on his side.". It now became evident that he could not be induced to march through the streets, and so Scott, to his great joy, led him back to his house, where Alice received him with gambols and great glee. Jumbo will now be left in peace for a fortnight, the large box on wheels being placed at the entrance of his house, so that he will be compelled to pass through it, and in this manner will become accustomed to its appearance. A number of letters from children, and from Fellows of the Zoological Society, have appeared in the papers, urging the repurchase of poor Jumbo, but it is stated that Mr. Barnum on Monday telegraphed: "Elephant to be shipped as soon as possible—spare no expense."

Jumbo is now twenty-one years old, having come to the gardens from Paris at the age of five, in exchange for some other animals, and then was about the size of a Shetland pony. He is now eleven feet high, and is the largest elephant in Europe, and, according to the testimony of African travelers, is a giant among African elephants, who rarely exceed the height of ten feet. Mr. Bartlett, *Land and Water* tells us, attributes this rapid and remarkable life to the good feeding, the careful housing, and constant grooming and attention which have been accorded to him during his stay in the gardens. He will travel across the Atlantic in one of the Monarch Line steamers, those vessels having long and wide hatchways—an important consideration in the transport of an animal of so large a size.

JUMBO'S FAREWELL TO ENGLAND.

Yesterday, March 23, Jumbo was successfully placed in the box which had been prepared for his transportation. At about 9:20 the doors of the stable were opened and Jumbo was led out for the last time into his paddock by Scott, the elephant being followed by Newman and the assistants. When Jumbo reached the entrance to the box he for an instant hesitated, and then, with his chains clanking behind him as he walked, he quietly stepped into it, and would have gone through into the grounds but for the well known "Whoa, Jumbo!" from Scott. As the elephant stopped the chains attached to his forelegs were slipped through holes at the sides of the box, and round strong staples bound with iron fitted to one of the uprights. Then inch by inch these were drawn up tight, so that Jumbo stood with his fore feet about three feet apart. Now came the task of hobbling the hind feet, and fixing them in the same way as the others. As fast as an attempt was made to pass the loop round his one foot he contrived to step upon it with the other, and evade it; now and again, as other means failed him, going down upon his knees and stretching himself to the utmost. Time after time did the attempt to snare him fail, but after about half an hour of patient work the hobble was fixed on the leg and the next instant passed around the staple. This was accomplished about half past 10, or two hours and a half from the commencement of the business. During the afternoon a number of men were digging away the ground in front of the box, and sloping it upward to form an inclined plane. When this was accomplished, and planks had been laid down, six strong horses were harnessed to the huge car, and the task of drawing it up to level ground commenced. . . . Night came on, and the work proceeded slow by lamplight. The car had traveled 100 yards in five hours. The night was clear and starlit, with a crescent moon in the sky and a chill wind blowing. Jumbo was protected from the keen air by tarpaulins stretched across the bars of the two ends of his box.

At 10 o'clock the horses were taken out and led away. At about 10:15 the elephant began moving about uneasily in his box, put his trunk out, played with the straw in front, fished up one of the nosebags of the horses, and afterward threw it out on to the head of an attendant. Then, less good humoredly, with short, quick jerks of his hind legs, he made his chains rattle again. Next he began to jog rapidly backward and forward, butting as he came forward against the front bars of his cage, and making the ponderous box move backward and forward with his weight. Great clouds of steam burst from his trunk into the cold night air. As he felt his strength tell he appeared to redouble his exertions—the box rattled, and its frame quivered at every blow. It seemed merely a question of time to break it. If he had continued these tactics long enough nothing could resist them. One of the attendants spoke to him, and quieted him for a moment, but Jumbo began again. At length Scott, who had been taking supper, returned; the elephant was calmed at once, and shortly after had food and water. It may be stated that Jumbo snapped like tow a four-inch rope which was used in fettering him yesterday morning.

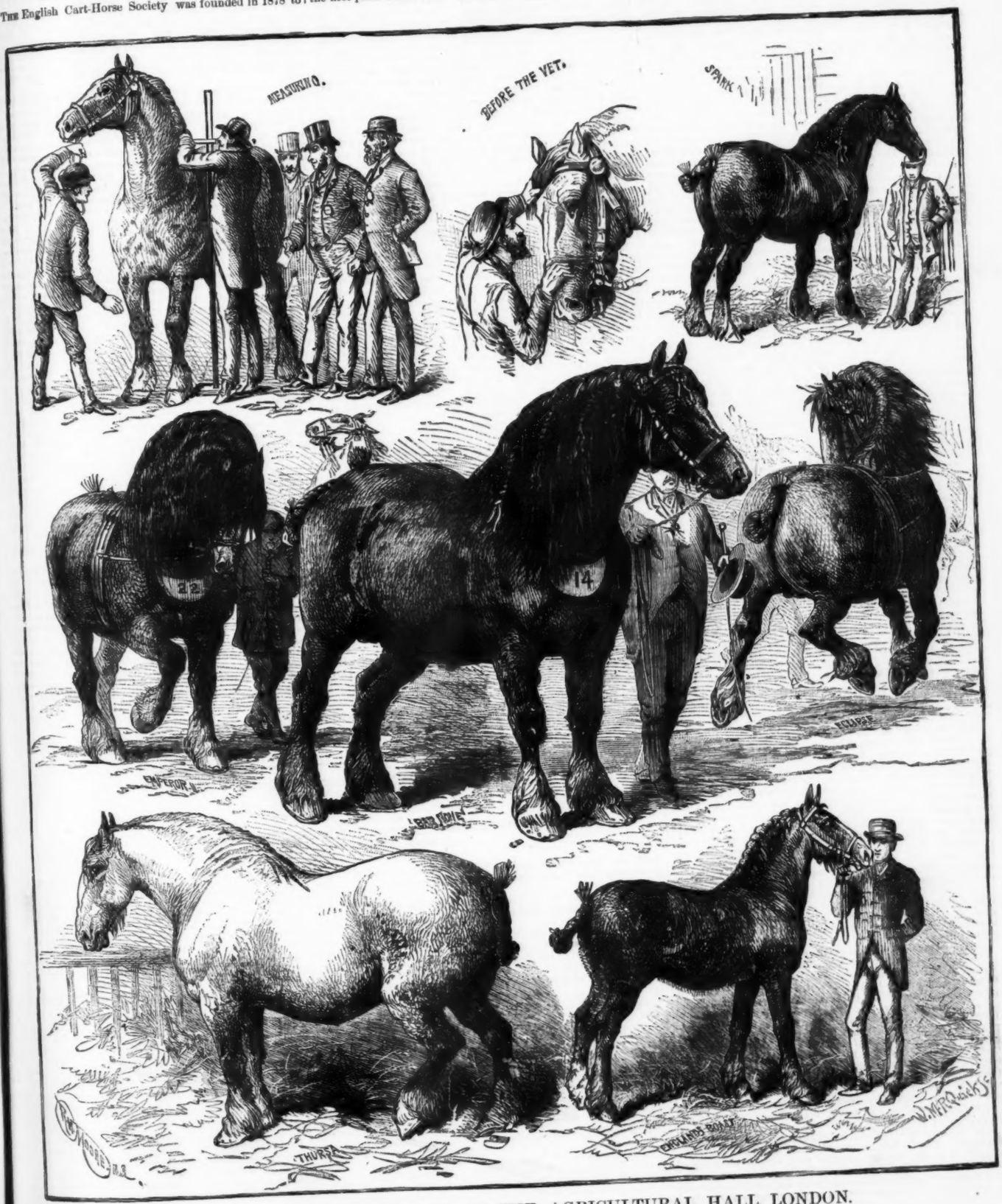
At a quarter past 11 Jumbo began to dance again, snorted, knelt down, worried his chains with his trunk, shook his box heavily, and would certainly have broken it if he had persisted; but at the command of his keeper he became quiet. At 12:15 the horses were put to; at ten minutes to 1 they tried to start, with ten horses harnessed two abreast, but the wheels had sunk so deep in the earth that it was impossible to move. Jacks were now employed to lift them, and at 1 o'clock a start was fairly made. At 1:25 the car was safely out of the gardens, and rattling off on the road to the docks.

The docks were reached at about half past 5 in the morning, the distance being about five miles. By this time it was almost daylight, and, although it was now too late to think of utilizing the early morning tide for enabling the

barge to leave the dock with Jumbo on board, it was decided to hoist the box on the lighter at once. Stout hempen ropes were passed round the structure in which Jumbo was confined; and both the elephant and his temporary prison-van, weighing together between ten and eleven tons, were hoisted into the air and gradually lowered into the barge Clarence, which floated alongside the dock.—*London Echo.*

ENGLISH CART-HORSE SHOW.

THE English Cart-Horse Society was founded in 1878 to promote improvement in the breeding of the "shire-bred" or old English heavy draught horse, and to distribute sound and healthy sires throughout the country. This society, under the patronage of the Prince of Wales, with the Hon. Edward Coke as president, and the Earl of Powis, the Earl of Ellesmere, and Earl Spencer as vice-presidents, has enrolled six hundred members, has compiled and published its third annual stud-book, and held in March last at the Agricultural Hall, London, its third annual show, for which, by special subscriptions, a prize fund of between £500 and £600 had been provided. The exhibition comprised 112 horses, 78 mares, and 15 geldings, each class represented by some animals of rare excellence. The first prize of the whole collection was fairly won by Mr. James Forshaw's Bar None, a seventeen hands bay with four white feet, from Nottinghamshire, but bred in Yorkshire, which won the first prize at Garstang last year. The second prize went to the same exhibitor's Tom of the Shires. The first prize in the second class was adjudged to Emperor II., a bay, twelve years old, belonging to Sir Richard Wallace. In the class of horses four years old, without limitation as to height, the first prize went to Mr. Walter Gilbey's magnificent horse Spark, which was the champion last year, and was also first at Derby. For three-year-olds the first prize was won by the Hon. Edward Coke's Conjurer, bred near Aylesbury. The Earl of Ellesmere was first for two-year-olds with Eclipse. The champion mare was Thursa, a noble gray, five years old, owned by Mr. Garrett Taylor, of Trowse, Norwich, but Buckinghamshire bred. There was a large gathering of company each day, and their Royal Highnesses the Prince and Princess of Wales and the Princesses Victoria and Maud were among the visitors.—*Illustrated London News.*



RECENT CART-HORSE SHOW AT THE AGRICULTURAL HALL, LONDON.

THE PHILOSOPHY OF ANIMAL COLORS.

By DR. ANDREW WILSON, F.R.S.E.

THERE is a suggestive passage in Butler's "Hudibras," which maintains that—

"Fools are known by looking wise,
As men find woodcocks by their eyes."

And if the axiom be correct, that a poet is only great when he is true to nature, it must be admitted that Butler has been singularly felicitous in this metaphor. Whoever has seen a woodcock in its ordinary summer plumage may form a good idea of the truth of the poetic remark. As that bird moves about among the fallen leaves of autumn, the grays, and browns, and yellows of its feathers mingle so beautifully with the like tints of its surroundings, that the animal is absolutely concealed from any view but the practiced eye of the sportsman. As has been remarked of the bird in question, even the very conspicuous and ornamental tail becomes hidden from view in a most singular fashion. Below, these tail-feathers exhibit a white color tinted with a silver sheen and marked with a deep black. Nothing more conspicuous than such an ornament can well be im-

agined; yet the tail and its belongings are, nevertheless, wonderfully concealed. For, as the bird reposes, these under lines and tints are placed downwards; and above, the ashen-gray tints mingle perfectly with the bird's surroundings. As the woodcock, therefore, rests amid its background of wood and its foreground of fallen leaves, every line of its plumage is made to assimilate so closely with the objects around, that the bird's presence, even a short distance off, is not suspected.

The woodcock is by no means alone in this harmony betwixt its plumage and its surroundings. The sand-grouse of the deserts, for instance, exhibit a like harmony. These birds cannot be detected, even as they run, amid the sand of their haunts—so closely imitated in the dull tints of their plumage is the tone of the desert wild. The well-known case of the ptarmigan is even more extraordinary still. In summer the bird shows a plumage of pearly gray, which conceals it perfectly as it lies on its bed of Scottish heather, mingled with the lichen and its kith and kin. But when the winter snows descend and coat the hillsides with a mantle of white, then a kindly nature still contrives concealment for the ptarmigan in a fresh suit of color. The pearly grays of summer are replaced by a plumage of snowy whiteness, and, save for its dark eye, there is little risk of the discovery of the bird by the unwary or unpracticed sportsman. The grouse and common partridge are not less perfectly protected. The hues of the grouse match the tints of the heather, and the partridge is almost as difficult to discover—say in a plowed field—as the ptarmigan on the hillside. The birds just mentioned are all *rasorial* birds; that is, they are allied to the type of the common fowl, and are typically ground-livers. Their tints, therefore, assimilate with those of the ground and with ground vegetation; and whatever may be the ultimate philosophy which shows the origin of such harmonies, it is very plain that the utilitarian is bound to read "protection" in every line of the story. Escape from their enemies must be favored by the correspondence in color to which we allude. The harmonies of color present the safest, and therefore the best foil, to the keenness of sight of the eagle, and to the agility of the falcon and its kind. It is different, indeed, with the songsters of the wood and grove. With well-developed powers of flight, and with a close refuge amid the foliage of the wood, the appearance of bright hues and tints in these birds is by no means disadvantageous. Another law—that of the development of color in relation to sex—has taken precedence of the regulation of color as a means of protection. If concealment be necessary, nature will teach the art of hiding in other ways than that whereby she contrives to make the partridge face danger with a stillness that almost rivals that of the stones, trustful in the harmony of her plumage that so closely matches her heather bed.

But there are wider fields open to the naturalist's survey of color and its meanings. Suppose that we peer for a moment into the class of fishes, we shall find the adaptation of color to surroundings illustrated in a very apt degree. Whoever has tried to spear a sole or flounder, for example, well knows that the excitement of the sport consists in the endeavor to follow out the axiom of Mrs. Glasse, and on the principle which that worthy lady laid down about "first catching your hare," to first catch your flounder. You cautiously and softly paddle out to shallow water in your punt, and you drift over the flat, sandy beach at a depth of from two to three feet. Below, the water is as clear as crystal. Here and there you see a lazy starfish on the march, exerting himself to the utmost, as he slowly extends ray after ray, and crawls at the rate of about a mile a month or so, by aid of his hundreds of sucker-feet. The sand-eels annoy you as they burrow downward and send up little clouds of dust on your approach; but the flounders you came to spear—where are they? and echo seems but to answer "where?" But the practiced sportsman bids you learn (as in all other sciences and arts) the first lesson—namely, how to see and observe. As your boat creeps along, he points to what seems a mere sandy lump, but in which his keener eye has detected the merest wriggle of a fin. Dash! goes the spear, and up comes a flounder, and as you watch the ground, you see dozens, it may be, of similar sandy patches swimming off in rapid alarm. The flounder's "back"—it is really the *side* of the fish—on which it lies, is white enough, as we know; but the "other side" is as close a representation of a sandy patch as you can see or as you can imagine. Small wonder, then, that in flounder-spearing you experience the difficulties which nature throws in the way of capture through likeness in color to the animal's surroundings. It is the same with soles, turbot, and with the skates and angel fishes. Watch the first flounder you see resting on the sandy bed of the aquarium tank, and you will receive ample proof of the truth of the foregoing remarks. And should you chance to see the lazy "monk," or angel fish, as it lies prone, heavy, and indolent in the highest degree in the flow of its tank, you may again understand something of the value of color as a means of protection to animal life.

In the case of those "queer fishes," the little sea-horses, or hippocampi, with heads like horses, and with a body which, at large, reminds one most forcibly of some figure from the Herald's College on a crest, concealment is effected in a slightly different fashion from that prevalent among the soles. Here the body, as a rule, possesses long streamers or fringes that mimic the seaweeds; so that, as the animal reposes, its body may well enough represent a stone, to which are attached fragments of marine vegetation. The Australian sea-horses, which live among red seaweeds, have streamers of that hue attached to their bodies, and the mimicry and imitation of their surroundings are thus very complete. Even their near neighbors, the pipe-fishes, with green bodies, when they fasten themselves to some fixed object, and "loll" in the water, may closely resemble an inert piece of green weed.

Among even the highest animals, protective coloring is common. A lion's hue matches the sand, as a tiger's stripes, according to Mr. Wallace, imitate very closely the foliage and trees amid which it crouches. The camel's coat is sandy like its desert; and the rabbits offer as plain examples as any of the color-harmony in question. The polar bear is white, like the arctic fox in winter dress; and the nocturnal rats and moles are dressed in shades the opposite of the ghost-like hues that become so conspicuous at night.

But, descending to still lower grades of life, we may discover examples of this "mimicry," not only of surroundings, but also of lifeless or inorganic objects, and of, it may be, plant structures as well, on the part of animals. The so-called "stick insects," or "walking twigs," as they are often called—the *Phasmidæ* of the naturalist—presents us with the most perfect reproductions of bits of dried twigs. A figure of one of these insects is before me as I write. It is represented climbing on the delicate branch of a shrub, and but for the expectation of what one is looking for, there would be considerable difficulty in determining which is insect and which plant. The bodies of these "twig insects"—which belong, by the way, to the *Orthoptera*, or that order which harbors the familiar crickets and grasshoppers—are represented by mere lines. The wings have disappeared, and it has been remarked that in their gait these insects exhibit a peculiar habit of using their legs in a singularly awkward fashion, and thus apparently aid the illusion of the spectator that he is regarding a dried twig, moved erratically by the wind.

More extraordinary still are the "leaf insects;" near allies, indeed, of the "walking sticks." Here "mimicry" of the plant proceeds so far as to fully justify the eminent naturalist's remarks, that it is strange to find the animal assuming a mimetic disguise and aping the actor's art. The wings in the "leaf insects" exactly imitate leaves. The venation, or arrangement of the veins in the leaf, is clearly seen, and in one form (*Phyllium*) even the chest and legs of the animal assume leaf-like characters. When such an insect rests amid foliage, the value of such a close resemblance to its plant surroundings as a means of protection can be readily understood. In some "leaf insects"—all of which are tropical species—the wings resemble leaves that are dried and withered. In others, the minute fungi that attack leaves are imitated. Mr. A. R. Wallace tells us that one of the "walking sticks" obtained by him in Borneo, "was covered over with foliaceous excrescences of a clear olive green color, so as exactly to resemble a stick grown over by a creeping moss or Jungermannia. The Dyak who brought it me assured me it was grown over with moss, though alive, and it was only after a most minute examination that I could convince myself it was not so."

Lastly, there may be noticed in connection with these curious traits of animal life, the fact that certain animals, themselves harmless and inoffensive, may assume the exact appearance of offensive neighbors. In this respect, certain butterflies are *facile principe*. Certain South American butterflies, known collectively under their family name of *Heliconidæ*, exhibit a brilliant coloration, but likewise possess a very strong odor; and, it may be presumed from the sequel, a highly disagreeable taste as well. They are highly conspicuous insects, and the under sides of their wings are as brilliantly colored as the upper surfaces; so that, even in repose, and when resting with the wings apposed over the back, they are readily enough seen. Their colors are prominent not to say gaudy. Yellows, reds, and whites commingle with blacks, blues, and other tints in a striking fashion. They are, further, by no means rapid fliers, and, putting the foregoing circumstances of their gaudy color and their slow movements together, no group of animals would seem more liable to the attacks of bird enemies than these Helicon butterflies. Yet the reverse is the case. So far from being decimated, their race flourishes apace, and this result is clearly due to the strong odor and nauseous taste they possess. The mere touch of a Helicon is in itself a pungent matter, which reminds one of nothing so much as the persistence of the muskrat's secretion, or the still more awful effluvium of the American skunk. Their neighbor butterflies may fall victims by the score to the rapacity of their feathered enemies, but the Helicons are spared from even the semblance of attack.

(To be continued.)

THREE SYSTEMS OF WIRE ROPE TRANSPORT.*

By WILLIAM THOMAS HENNEY CARRINGTON, Assoc. M. Inst. C. E.

THE author proposes to describe three systems of wire rope transport, each of which he has successfully applied on many occasions. The examples, hereafter referred to in detail, are those which in his opinion will give the best idea of the applicability and capabilities of each system.

They are—

(1) An example of the single running rope system, invented by Mr. Charles Hodgson, with improvements by the author.

(2) An example of the double fixed rope system, worked on the gravitation plan.

(3) An example of the single fixed rope system.

A fourth system, of two fixed ropes, has been described in the Minutes of Proceedings, by Mr. Churchward, Assoc. M. Inst. C. E., in a paper on the Monte Penna Wire Ropeway, lately erected by him from the author's designs.

It is believed the following details will show that the several systems of wire rope transport will form a useful and economical means of moving materials in situations where a railway or a road would be too costly or impracticable.

RUNNING ROPE SYSTEM.

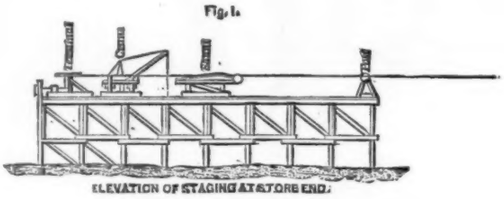
The example of the single running rope system selected for description is that of a line erected in the Cape de Verd Islands, at Messrs. Cory Brothers & Company's coal depot, shown in Figs. 1, 2, and 3. Its total length is 500 yards, of which length about 320 yards extend along the beach, and about 80 yards at right angles to the longer section to the end of a pier, where the coal is received and dispatched. The ropeway was required to be able to carry 15 tons of coal per hour in either direction, and the motion of the rope was to be utilized in working cranes at each terminal for raising or lowering coal. The coal is brought to the pier in bulk, in barges from the colliers, and the buckets of the wire ropeway are lowered into the barges by a crane, and when filled are again raised and sent off on the ropeway to the depot, at its further end, where a quantity of about 10,000 tons is usually stored. To supply the steamers calling at the island the coal is filled at the store into bags holding 2 cwt., raised by a crane to the level of the wire ropeway, and carried by it back to the barges at the end of the pier.

The driving gear with its steam engine is placed at the point where the two sections of the wire ropeway meet at right angles. It consists of a massive wooden frame, carrying an upright shaft fitted at its upper end with two drums 8 feet in diameter, lying one on the top of the other, the ropes of the sections passing round these two drums, and being driven by them. At the lower end of the vertical shaft bevel gear is fixed, by which the motion of the steam engine is communicated to the drums. The usual shunt rails allow the loads to pass round the angle thus formed.

The steam engine is of 16 horse power nominal, has two cylinders, and is fitted with a surface condenser, it being impossible to obtain any fresh water for the boiler in the island except by distillation. The boiler is of the ordinary horizontal multitubular type, cylindrical throughout; it is worked up to a pressure of 60 lb. The terminal at the end of the shorter section on the pier head carries the horizontal drum round which the tramway rope passes, and a long horseshoe shaped rail. On this frame is also mounted a crane, having a radius of 17 feet, and worked by shafting from the engine. This crane is manipulated by a friction clutch, actuated by a lever on the top of the frame on which the man stands and has a clear view of the work going on below. Four buckets, each holding 2½ cwt., are lifted at a speed of 80 feet per minute, and deposited on to a deck alongside the terminal frame. The buckets are then pushed, singly, down an inclined plane, so arranged that they engage themselves on the hangers which, with their saddles, carry them on the line rope. In a similar way the empty buckets arriving, or the sacks for delivery, are detached and lowered into the barge. The terminal at the end of the longer section at the coal store is placed on a wooden platform, about 20 feet above the ground, and 120 feet long. At the end of this, furthest from the driving station, is fixed a horizontal drum 8 feet in diameter, carried on a strong wooden frame, round which the line rope passes, and which can be drawn back when required to take up any extension. The motion of the rope actuates the drum, which, by a pair of bevel wheels, turns a square shaft, extending along the center of the platform for its whole length.

A crane of similar construction to that on the pier head is placed on the platform in front of the terminal, and can be moved from end to end, deriving motion from the line rope through the square shaft at any point. The jib of this crane is long enough to enable loads to be hoisted on either side of the platform, and to be put down just behind the traveling shunt frame, which stands about 15 feet in front of the crane, and which is arranged to slide up and down the full length of the platform in conjunction with it. Thus the sacks of coal, having been raised from the ground, are placed at the foot of the shunt stage, by which they are, having been hung on the hangers, pushed on to the moving rope and transported to the pier. When coal is being brought to the store, it is tipped into an inclined shoot out of the buckets while they hang on the rail of the moving shunt. It will be seen from the arrangements described that the coal can be hoisted out of the barge at the pier head, transported to the terminal depot, and delivered into store, where it is duly put into sacks for redelivery to the steamers; and when this is required the sacks of coal can be lifted up to the ropeway, a height of 20 feet, transported to the pier head, and deposited into the barges.

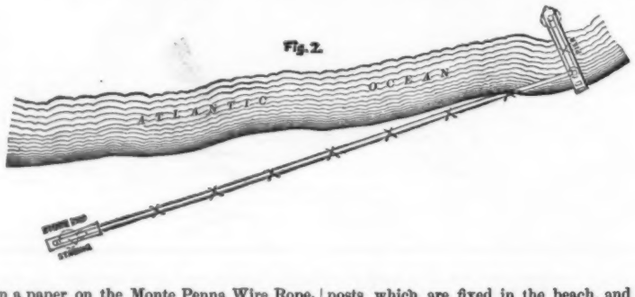
Fig. 1.



ELEVATION OF STAGING AT STORE END.

The rope is supported on the longer section by seven posts, which are fixed in the beach, and are of the usual construction, about 15 feet high; these posts carry bearing pulleys 2 feet in diameter, grooved to fit the wire rope, which is of crucible steel of a breaking strain of 16 tons. The rope is run at a speed of 3½ miles per hour. This ropeway is carried about 130,000 tons. Though it was only designed to lift and carry 15 tons per hour, it has on emergencies conveyed more than 25 tons in an hour.

Fig. 2.



The cost of maintenance of the rope has been about ½d. per ton, that of the machinery about ½d., chiefly owing to the breaking of the buckets by rough use when hoisting. Thus the cost of maintenance may be taken at 1d. per ton, not allowing for the special duty levied on the renewals on

* From Selected Papers of the Institution of Civil Engineers.

entering the island. The cost of labor employed in working this ropeway has been greater than usual, as natives are employed. It amounts to 1d. per ton, including tipping the coal into store, and attending the engine. The cost of working the crane and filling the buckets in the barge has been about ½d. per ton. The engine burns 7 cwt. of coal every twelve hours. The operations are generally superintended by an English foreman, who also looks after the other mechanical work of the establishment.

The cost of these works complete erected on the spot, but exclusive of freight and customs duty, was about £2,500, which also included the large staging at the depot, and the woodwork throughout. The whole of the materials were fitted together in England, marked and taken to pieces again. The erection on the site occupied about three months, and was carried out by Mr. W. P. Churchward, Assoc. M. Inst. C. E., from the designs and under the general supervision of the author.

DOUBLE FIXED ROPE SYSTEM.

The first example of the system of transport on fixed wire ropes is that of a series of self-acting inclines of a total length of 2,844 yards, forming a means of conveyance for the lead ore from the mines of the Sentein Mining Company, in the Pyrenees, near St. Girons, France. These mines, which are of great extent and unusual richness, are situated at a height of about 7,000 feet above the sea near the summit of a mule pass over the Pyrenees. Though they have been worked for many years, their elevated position has prevented them from becoming a financial success, the distance to the dressing floors being two miles in a direct line, and the fall about 3,000 feet. Immense expense was incurred by the former proprietors in constructing a cart road up to the mines, which, though extremely steep at many points and very narrow, required to be about ten miles long to connect the mines with the dressing floors.

On the property coming into the hands of the Sentein Mining Company, the question of transport presented itself as vitally important to the profitable working of the mine. With the road it was possible to bring down by carts about 30 tons per day of lead ore, at a cost of about 8s. per ton, but this was only practicable in good weather, and in winter was impassable owing to the road snow. The directors of the Sentein Company applied to the author to advise them on the question of applying wire rope transport for the greater part of the distance. He found it possible to recommend the application of a series of self-acting wire rope inclines (common on a small scale in the district) by which the ore could be brought down to a point about three quarters of a mile from the works, from whence there was a good cart road. This suggestion was adopted, and wire ropeways were erected from the designs of the author (Figs. 4, 5, 6, and 7).

The inclines are five in number; the lower terminals of one join the upper terminals of the next, a suitable spot for these junctions being found at the ends or sides of the spurs of the mountain near the line of the wire ropeway.

The lengths and inclinations of the sections are as follow:

No.	Yards long.	Yards fall.
1	271	33
2	675	230
3	410	90
4	978	430
5	510	130
Totals	2,844	913

No. 1 incline commences at the mouth of the mine, and forms a junction with No. 2 incline at the edge of a cliff about 300 feet high. No. 2 incline crosses a span of 675 yards, and joins No. 3 incline on an elevated point on the steep side of the mountain, a small platform being cut out of its side for that purpose. No. 3 incline, stretching across a deep ravine, effects a junction with No. 4 incline at the extreme end of a spur of the mountain, a flat space being cut off its pointed top, the side shelving at an angle of 60° with the horizon. No. 4 incline, spanning a valley 978 yards across, and about 1,500 feet deep, joins No. 5 incline on the side of the mountain. No. 5 incline stretches thence down into the bottom of the valley, terminating close to the cart-road to the works.

These inclines are identical in principle, differing only in length and inclination. They consist of two crucible steel fixed ropes, of 75 tons breaking strain, anchored at the upper end, and stretched across the space between the terminals, the lower end being held by a pair of blocks fitted with Bullivant's flexible steel wire rope, by which the fixed ropes are tightened. At each end they pass over a massive masonry saddle. The blocks by which they are tightened are fitted with a long flexible rope, to allow of their being slackened out enough to lie on the ground for the purpose of repairs; the strain put on them is about 12 tons. The carriers for the ore are made of steel plates, measure about 2 feet 9 inches long by 2 feet wide and 2 feet deep, and are hung on the fixed ropes by a curved hanger fitting into a pair of plates carrying between them two deeply grooved steel wheels 15 inches in diameter on the tread, which fits the fixed rope. These plates also carry a small wheel under the fixed rope, which is placed so as not to touch it, but to prevent the larger grooved wheels being jerked off.

The carriers empty by the bottoms falling on the turning of a handle fixed to their sides. They are intended to carry from 14 to 15 cwt. each. One of these is placed on each of the two parallel fixed ropes, and the two are connected by a light wire rope of 7 tons breaking strain, of such a length that when one carrier is at the upper end of one fixed rope the other is at the lower end of the second parallel rope. Thus, when one carrier is charged with 14 cwt. of ore while standing on the upper end of the fixed rope, it runs down this rope dragging up the empty carrier on the second fixed rope by means of the light hauling rope, the speed being governed by a powerful brake. This hauling rope passes round a brake gear at the end of the incline. It consists of two vertical wheels, 5 feet in diameter, having grooved wooden rims, placed 5 feet apart, each wheel being fitted with a powerful brake.

The hauling rope passes over the first of these, next round a wheel 5 feet in diameter, placed horizontally in front at the feet of the two vertical wheels, and then round the second vertical wheel; by this means the adhesion on the two vertical brake-wheels is equal to rather more than that derived from two half turns on these wheels. A second hauling rope of the same size connects the carriers by passing round a horizontal drum at the lower end of the incline, which is arranged to be drawn back by means of a screw, to regulate the tension on both the hauling ropes.

Owing to the great elevation at which most of the stations are situated, the erection of the works was difficult and expensive. The carriage of the ropes up the mountain was especially so; their total was about 30 tons, and it had to be divided into coils of 20 cwt. each, as it was impossible to take up by cart a heavier weight.

In conveying these 20 cwt. coils to the upper parts of the line five horses were required to each, and only one coil per day could be delivered. The transport of the machinery, carriers, etc., was equally difficult and expensive. In building the masonry saddles, owing to the frequent occurrence of frost at night, even during the earlier part of the autumn, it was impossible to place reliance on the mortar used, and the masonry saddles were therefore strengthened with massive timber trestles fixed round the stonework, which assisted them in taking part of the vertical strain. On a future occasion, in such a situation, it would be advisable to use timber trestles only. By arranging the junctions of the adjoining sections the strain of one balanced to a considerable extent that of the other, and by the anchorage of the fixed ropes of each of these sections to the same foundation beam, which was placed under the saddles, and also strongly bolted down to the rock, the weight of the masonry materially increased their security.

As the inclines joined one another at a horizontal angle and on very confined spaces of ground, it was found necessary to transfer the contents of the carriers from one section to the next, by small tip wagons running on a short and slightly inclined rail between the point where the loaded carrier stopped to discharge and that where the empty carrier stood at the top of the adjoining section. These wagons ran easily, with the assistance of one man, who, when he had discharged the contents into the empty carrier, pushed it back into its place, ready to receive the contents of the next loaded one.

There was, of course, a similar arrangement on each side of each station; had it been possible to obtain better and more spacious sites for the stations, the usual arrangement would have been adopted—of placing the anchorages so that one carrier could tip its contents direct into the empty carrier on the adjoining section, and the lower ends of the fixed ropes could have been anchored by means of weights.

In working these inclines it was necessary to have three men at each station; one man at the brake gear, and the other two men attending to the emptying of the loaded carriers and the transmission of their contents to the empty carriers on the next section. The man at the brake had an uninterrupted view of the whole section. The speed at which the carriers are allowed to run is about 25 miles per hour; when the brakemen had become accustomed to their duties, they could regulate their speed to a nicety, and bring the carriers to a standstill at the proper points with perfect smoothness and accuracy.

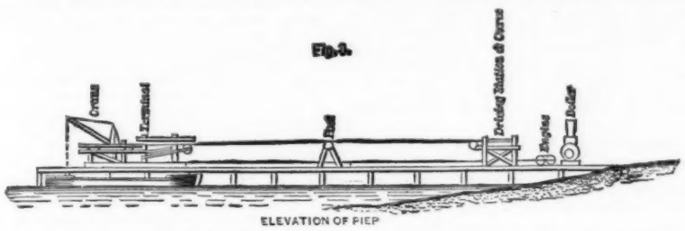
The quantity of ore which can be transported by these inclines depends, of course, on what can be got over the longest section; and while, owing to the exigencies of the route, it was necessary that the sections should vary greatly in length, it was attempted to equalize their carrying capabilities, by making the longer sections steeper than the shorter ones, thus enabling the carriers to be run on the former at a higher speed. To some extent this was successful. In putting up a series of inclines, such as those now described, it will be advisable to equalize, as far as possible, the carrying powers of each section.

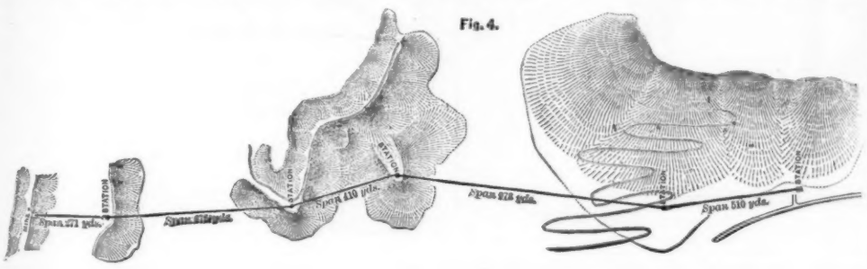
The amount of ore which has been regularly brought down by this system has been from 70 to 80 tons per day, but if sufficient mineral were provided, 100 tons per day could be transported. A trial with the 675 yards section, before the men had become thoroughly acquainted with its working, proved that 12 tons per hour could be taken down. The cost of carriage is about 2s. 0d. per ton, exclusive of maintenance, which may be taken at 1s. 6d. per ton, or a total cost of 3s. 6d. The maintenance charge at these works will be exceptionally heavy, owing to their very exposed situation, and to the fact that for two months of the winter at least no work can be done, the plant, meanwhile, being exposed to the full deteriorating action of the weather.

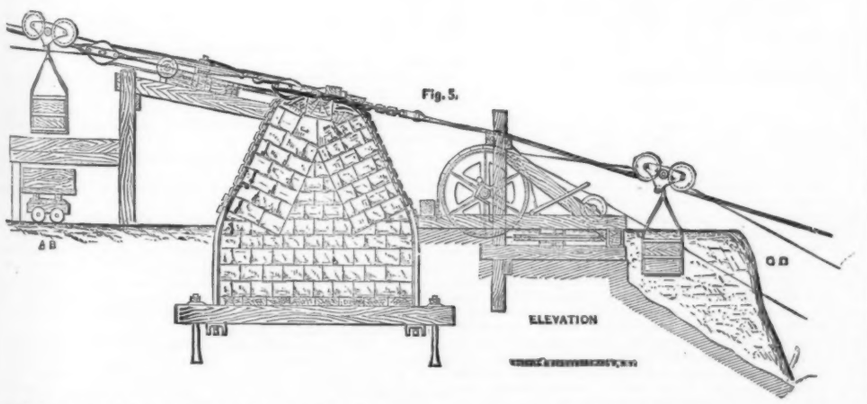
By this ropeway the transport of mineral has been carried on without stoppage while the roads were buried in snow to a depth of several feet. The works have thus been supplied with ore for a much longer portion of the year than would have been possible by any other means of transport.

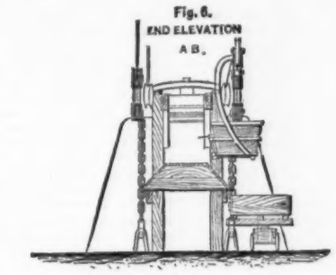
The cost of the whole work was about £5,000, of which only £2,200 were for the materials, the balance being for customs duty, freight, delivery from the nearest railway, 25 miles distant, cartage up the mountain, and erection.

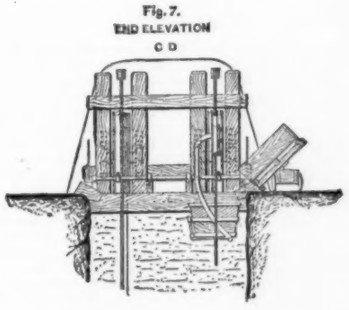
The work was erected in the nine months from August to April, during six of which only could work be efficiently carried on, and in the remaining three months the weather and other causes prevented progress. Had the work been commenced earlier in the summer, it could probably have been completed in five months, and much of the erection would have been of far better quality.









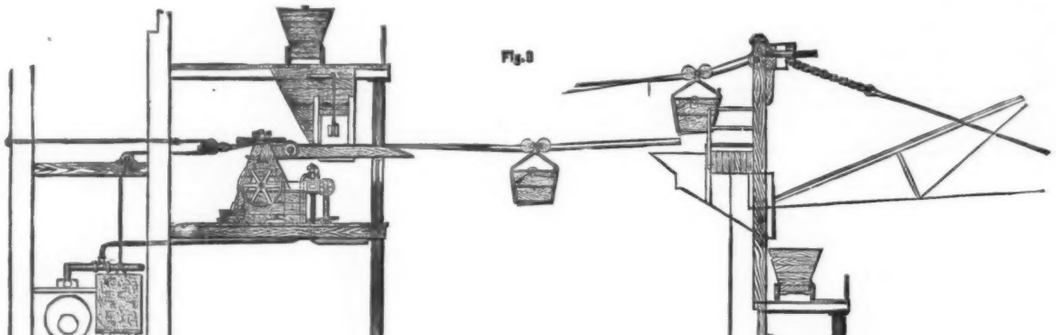


SINGLE FIXED ROPE SYSTEM.

The second example of wire rope transport on fixed ropes is a short length erected at the Nine Elms Works of the London Gas Light Company.

It was required to provide a means of transporting 24 tons per hour of gas coal across a dock in the above works to supply one of the retort houses. The point from which the coal was to be taken was about twelve feet above the ground, and it was required to deliver it into a hopper at the level of about 35 feet, the distance across the dock being 450 feet, and the incline consequently about 1 in 19 against the load. The company's engineer and manager, Mr. Robert Morton, M. Inst. C. E., requested the author to prepare a scheme for his consideration for doing this by wire rope transport, and finally the arrangement shown by Fig. 8 was adopted.

It consists of a single rope of crucible steel wire, of 40 tons breaking strain, stretched across the dock. The upper end is fixed to a timber framing, attached to the retort house at about 45 feet above the ground, the attachment on which is tied back by another wire rope, exactly in the same line as that over the dock, the end of which is anchored to the opposite wall of the house near the ground. The lower end of the rope across the dock is held by a weight of 4 tons, acting on the double purchase system, which thus exerts a strain of about 8 tons; by this means the strain on the rope is constant, whether the loaded truck is running on it or not. The truck is made of iron, and holds about 17 cwt. of coal; it is provided with a curved hanger fitting into a running head which rests on a fixed rope. By a simple arrangement of a lever and catch, the bottom of the truck is let fall, and discharges its contents; the lever and catch are placed on the side of the truck, and thus the attendant who stands at the delivery terminal can empty the truck and replace the bottom with very little effort and loss of time. At the lower or loading end the truck runs off the rope on to a rail, on which it stands under the door of a hopper containing the coal to be transported. This is let into the truck by a sliding door conveniently worked. The truck is made to stand on the rail under the hopper, in order that it shall be supported rigidly, and at the same height during this operation, which it could not do had it remained on the rope. When loaded, it is drawn across to the discharging end, hanging on the fixed rope by means of the running head, at a speed of five miles per hour, up a nominal incline of 1 in 19, but owing to the bend of the rope this is often as much as 1 in 10. The running head which has been referred to is formed of two strong iron plates, carrying between them, one near each end, two deeply grooved cast iron wheels, about 9 inches in diameter on the tread, and made to fit the fixed rope. The edges of their rims are turned true, so as to run on the rail under the loading hopper before referred to. These wheels are carried on steel pins fitted between the wrought iron plates, through which, between the wheels, the curved hanger attached to the truck also passes.



This head with its suspended truck is moved along the fixed rope by a small crucible steel wire rope of about 4½ tons breaking strain, which passes round a horizontal drum fixed at the upper end of the line to the wooden frame which carries the attachment of the fixed rope, and is put in motion by a simple arrangement of driving gear at the lower end of the line. This driving gear consists of a horizontal wood rimmed drum driven by bevel gearing, so arranged that it may be moved at five miles per hour in the forward, and at ten miles per hour in the backward direction. The driving drum is fitted with two parallel grooves, and by means of a smaller drum placed at one side of it, the hauling rope may be made to pass twice round certains of its circumference, and thus increase its driving power. This contrivance also gives a means of taking up any small amount of stretch which may take place in the hauling rope.

The whole of the driving gear is carried on a substantial A shaped wooden frame, and alongside it is placed a small engine of 6 nominal horse power to provide the motive force. All the handles which control the motion of the driving gear, as well as that of a powerful brake on the fly-wheel of the engine, and that by which the loading hopper door is opened, are brought to a convenient spot where the driver can stand, who thus, without moving from his place, has control over all. In case the engine, which is of Tangye's "Soho" type, and of very short stroke, should stop on its center, a ratchet lever arrangement is placed on the end of the crank shaft, so that the driver can move it off with ease. In working this ropeway it is found that 30 lb. of steam will drive the engine at the required speed, thus giving 8 horse power actual. The labor employed when working to the full capacity is as follows: One driver, one trimmer, and one man at the discharging end.

The method of proceeding is as follows: The truck having arrived under the loading hopper, the driver pulls up the door, and the bucket is filled, the trimmer with a shovel leveling the coal as it falls; the driver, shutting the hopper door, engages the forward motion of the driving gear, and the truck is drawn across to the discharging hopper, about 5 feet square, at the upper end of the line some 450 feet distant; the driver, putting on the brake, stops the motion, and on receiving a signal from the man at the upper end that he has emptied the truck and replaced the bottom, puts the backward gear in motion, and draws the truck back to the loading hopper at a speed of ten miles per hour. In regular working the whole of the operations described occupy two minutes, and thus 30 runs are made in the hour. At a trial, however, it was found possible to load, transport, and empty ten trucks in fifteen minutes, or about 30 tons per hour.

Since this line has been at work a small apparatus has been fixed to the driving gear, by which the driver can stop the truck exactly over the hopper. This was previously effected by placing a mark on the hauling rope, but owing to much of the work being done while it is dark, a more convenient arrangement was found advisable.

The labor is paid for at the rate of 0·88d. per ton. The renewal of ropes, wheels, and general maintenance may be taken at 0·4d., of which the maintenance of the wire ropes is 0·26d. In all, excepting fuel, which in this case is the gas coke on the premises, the cost of loading, transporting for 150 yards up an incline of 1 in 19, and discharging, is 1·28d. per ton. The cost of the machinery ropes and steam engine for this work was £340. The erection and the platforms were provided by the London Gas Light Company.

Such a ropeway is very suitable for transporting materials across a space where supports are inadmissible, such as ravines, rivers, from shore to a pier head, or pontoon in deep water, etc. The loads carried may be as heavy as 20 or even 30 cwt. net, as it becomes, under such circumstances, chiefly a question of the strength of the rope. The author, some years ago, erected a similar means of transport over a valley 1,000 yards wide, without intermediate support, and in that case loads of 15 cwt. were moved.

The author trusts that by the examples he has given of three descriptions of wire rope transport, he has shown the applicability of the system under circumstances where the use of any other means would be either costly or impossible, and in such cases he believes this system may be advantageously used.

[Continued from SCIENTIFIC AMERICAN SUPPLEMENT, No. 327, page 5217.]

ON WARMING AND VENTILATING OCCUPIED BUILDINGS.

By ARTHUR MORIN, Director of the Conservatory of Arts and Trades, Paris.*

ASYLUMS.

95. ASYLUMS, designed for the old, insane, or infirm, do not require, for salubrity, as much ventilation as hospitals. A renewal of air at the rate of 1,000 cubic feet of air an hour for each individual during the day and 1,400 cubic feet at night will be sufficient. It will then only be necessary to adopt the plans and the dimensions which have been given in detail for hospitals.

For heating during the winter, if the rooms are not very large, ventilating fire-places should be used, which will also secure the renewal of air. But for spring, summer, and autumn, it will be necessary to have recourse, for the removal of foul air, to the use of a ventilating-chimney and the arrangements before mentioned.

CHURCHES.

96. The great size of churches, the constant opening of their doors, the extent of glazed windows—always imperfectly closed—the openings in the vaults for the suspension of lamps or draperies and for the passage of bell-ropes, seem in general to render unnecessary the adoption of special arrangements for the admission and the removal of air, and reduce for the winter the question to that of warming.

For the churches of large cities, frequented at many hours of the day, it seems economical to keep up an active fire, constantly, day and night. Either hot-air heaters, with chambers for the admission of cold air, or hot-water heaters, may be used. The first suit more particularly the small churches, where a single heater, placed about the middle of the building, will suffice. The second, which carry heat to great distances, and give, besides, a more equable temperature, should be preferred for large churches. They have, in addition, the advantage of being readily adapted to ventilate certain attached places, such as catechising-rooms, where the air is constantly vitiated by the presence of many children.

What is most necessary to warm in churches is the floor itself. For this purpose it would be well to make the hot-water pipes branch out under many parts of the floor, and limit the number of fresh-air openings. This arrangement is similar to that of which traces are found in Roman constructions.

The air to be warmed by the heaters is taken from outside. A sufficient number of pipes in the aisles and passages admit the air through numerous openings placed in the vertical faces of the walls, or in the bases of the columns, a little above the floor, and not at the floor-level, as is often wrongly done.

During the summer season, the interior of churches, strongly heated during the day by the action of the sun on the roof and through the large windows, is often uncomfortable to stay in, especially in the morning. It would be easy to avoid this trouble by arranging a number of windows to be opened at night, in order to admit the fresh air, and to be shut in the morning. The interior, thus cooled during the night, would be less warmed during the day.

These precautions, much neglected in France, where the heat of summer seldom proves unpleasant, are regularly carried out in Rome, where it lasts a long time. A rule of the custodians of St. Peter's requires that the windows of the upper galleries be opened every evening in summer and closed every morning.

What precedes only applies to ordinary churches; but in the case of chapels or subterranean churches, the interior height of which is very limited, and which are often occupied by a large number of worshipers and fully lighted up, it becomes necessary to secure the renewal of air and the removal of the hot gases arising from the lights. The plans proposed in § 64 for night drawing schools should then be adopted, producing a renewal of air at least five or six times an hour.

In churches where great ceremonies require the use of large canopies, preventing the circulation of the air, and in which a great number of candles occasion often an extraordinary elevation of temperature,* it is very important that the construction should allow of forming, in the upper or lateral portion, as many openings as possible in order to allow the external air to flow in with a velocity which will be less the greater the number of these openings and the more uniformly they are distributed. In this way will be avoided the, at times, unendurable currents of air produced by the doors and the elevation of temperature.

In winter, at the time of thaws after great cold, especially in the north, there is produced on the walls, and still more on the ceiling, a condensation of vapor, which often produces a sort of rain that affects the paintings. In such cases, it would be well to carry the warm air supplied by the heaters at about from 140° to 175° directly to the upper part of these edifices at the springing of the arches, in order to keep the vapor arising from the people in the lower portions of the church from condensing.

RAILROAD STATIONS.

97. As an example of cases where it is proper to act contrary to the general rules given before, we will specify the methods to be adopted for railroad stations, for markets, and for large buildings such as those for exhibitions.

These immense buildings, covered in most cases with glass roofs, which often leave only a very small space for the escape of the smoke and steam of the locomotives and of the hot air in summer, sometimes become unendurable for the employes. One end of the building is almost entirely shut in by the gable wall containing the main entrance; the other usually has an opening only high enough for the passage of the locomotive; the sides occupied on the ground-level by waiting rooms, etc., and on the second and third floors by offices, do not allow the air to have access to the building, and in the hot season the temperature rises near the ground-level to 104°, 113°, and even 122°, as has been observed at the stations of the Lyons, Eastern, and Strasburg railroads.

In order to remedy this state of things, it is necessary to raise the skylights on the roof, not only because they are too low, but because in winter they cool the smoke and partially condense the escape steam of the engine, and thus interfere with its removal.

Instead of placing the skylights at the ridge of the roof, it would seem better to place them near the eaves, making them, as at present, equal to one-fourth or one-third the total surface.

The ventilating opening should be formed by two vertical walls of sheet iron about 10 feet high, leaving between them a passage extending the whole length of the roof, the breadth of which should be calculated so as to renew the air of the station at least twice or three times an hour, on the supposition that the heat of the sun in summer is sufficient to produce, in a sheet iron chimney 10 feet high, a velocity of from 1¼ to 2 feet a second.

To replace regularly the air removed without producing unpleasant currents at the end-openings of the station, it is necessary to increase the number of openings for admission of air, and place them as uniformly as possible throughout the extent of the station, and also to make large doorways in the two ends of the building. The total area of the fresh-air openings should be such that, with a velocity of at most 16 to 20 inches a second, a volume of air may enter into the station equal to twice or three times its cubical capacity.

98. *Sprinkling of roofs.*—In addition to the preceding arrangements, proper for all seasons, it would be well, in hot weather, to keep up a constant sprinkling of the roof, commencing at seven or eight o'clock in the morning and lasting till five o'clock in the evening, using about 4½ cubic feet of water an hour to every 100 square feet of roof surface.

This sprinkling, which will be sufficient to prevent the heating of the roof by the action of the solar rays, added to the continued aeration, will maintain the temperature within convenient limits during the hot season.

99. *Example.*—The Orleans station is 348 feet long, 92 feet wide, 26 feet high at the springing-line, and 44 feet to the ridge. Its cubical content is about 1,130,000 cubic feet.

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* Translated for the Smithsonian Institution by Clarence B. Young.

* In a great funeral ceremony at Notre Dame, Paris, the heat was such that the wax tapers began to melt.

To renew the air three times an hour, it should carry off $\frac{3 \times 1,186,000}{3,600} = 942$ cubic feet a second. The velocity which the solar heat may give to the escaping air being estimated at but $1\frac{5}{8}$ feet a second, the sectional area of the ventilating-space should be 574 square feet; and if the ventilating passage is carried the whole length of the roof, which is 328 feet, it would suffice to make it 1 foot 9 inches wide. But as the part where there is most smoke and steam is usually near the end at which the trains leave, instead of making the ventilating opening extend the whole length of the station, it would be better to give it greater breadth and less length, still retaining the same sectional area.

COURTS AND COVERED MARKETS.

100. Similar arrangements should be adopted in the case of courts and for all covered markets.

In the latter, where blinds are usually placed in the windows, the introduction of air is easily provided for, and it is particularly the removal of foul air that requires attention.

GLASS ROOFS AND CEILINGS.

101. *Influence of glazed roofs and ceilings during the winter.*—If in the summer season the glazed roofs of stations and covered courts present the inconvenience of producing a heating effect, which it is necessary to overcome, in winter they have the contrary defect, which often leads to very disagreeable results.

The conductibility of thin glass then leads to a considerable cooling of the interior layers of air in contact with the glass; this air, becoming denser than that below, descends, and is constantly replaced by more, which is likewise cooled, and by this continued movement the rooms thus covered become very difficult to warm.

To these troubles is added that of the motion of the cold air, which naturally flows toward the chimneys, or the discharge openings, if there are any, so that the occupants feel a descending current of cold air, the more unpleasant the nearer they are to the chimney or the discharge openings.

If the glass roof is simple, and has, as is almost inevitably the case, joints, through which the external air—much colder than that in contact with the internal surface—penetrates into the room, the effects which have been mentioned become more sensible and disagreeable. There is also the danger that water will enter during rain storms.

It is, then, necessary in occupied buildings, when similar plans are adopted for lighting, to place under the roof a glass ceiling with as few joints as possible, and in the loft thus formed and limited above and below, to provide heating arrangements which will prevent the cooling of the ceiling, and thus to avoid the cold air currents which have just been referred to.

102. *Observations at Château de Ferrières.*—The most striking example of these effects which I have had occasion to observe is presented by the great reception hall of the Château de Ferrières, and it has furnished me with some facts which enable me to determine the amount of heat which such glass roofs may transmit, and, consequently, to determine approximately the methods of heating to be employed to prevent this cooling.

The main reception room of the Chateau de Ferrières, called the hall, is 75 feet long and 40 feet wide, or 3,000 square feet in area.

It is completely surrounded by other reception rooms, corridors, vestibules, etc. By means of heaters, all these are comfortably warmed, as well as the reception room, which has no side windows, but is lighted by a glass ceiling with a surface of 1,635 square feet, covered by a glass roof in seven sections, having together 2,459 square feet of cooling surface.

A large fire place, in the form of a monument, placed on one of the long sides of the room, completes its system of heating.

When in winter the space between the glass roof and ceiling is not warmed during the day, the effects previously mentioned become the most unpleasant. The considerable draught of air produced by the fire-place draws to it the air cooled by contact with the ceiling; and the vicinity of this fire-place, to which persons are naturally drawn by a bright fire, becomes unendurable.

At night, the room is lighted up by 1,000 gas burners above the ceiling, which consume 3,500 cubic feet of gas an hour; there being then about one burner to every three square feet of floor surface in the room. The heat given out by this abundant combustion more than suffices to prevent the cooling of the air of the room and the unpleasant effects which would result from it.

To obtain, at least to a certain degree, the same result during the day, it has been found necessary to keep up coke fires in four cast iron stoves, placed in the roof space, in order to maintain there a temperature higher than that of the room.

Observations made on the consumption of coke during the day and of gas at night, as well as upon the internal and external temperatures, enable us to calculate at least approximately the amount of heat required in the space between the glass roof and ceiling in order to prevent the unpleasant cooling effect.

For this purpose, calling—

C the number of units of heat which can pass in an hour through a pane of glass having the surface S;
T the temperature of the air on the warmer side;
T′ that of the air on the colder side;
K a constant coefficient, representing the number of units of heat to a square foot of glass surface, and to a degree of difference of temperature between the two faces:

The amount of heat passing in an hour through a glass ceiling or roof will be given by the formula—

$$C = K\,S\,(T - T')$$

Engineers only admit for the coefficient K the value K = 1, while the data obtained at Ferrières seem to show that for a double glass covering—that is to say, a glass roof and a glass ceiling—it should have the value K = 3, and for a single covering K = 4, especially as in the latter case cold air might penetrate into the interior through the joints of the glass.

According to these values, allowing that the developed surface S of the roof is one and a half times that of the glass ceiling S, the amount of coal to be burned in the coldest weather may be calculated as follows:

Let—

S = 1,000 square feet;
S′ = 1,500 square feet;
The temperature of the external air be 14°;
The temperature to be maintained within the roof be 113°;
The temperature of the room, 59°:

The amount of heat passing off through the glass roof will be—

$C = 3 \times 1,500\ (113 - 4) = \ldots\ldots\ldots\ldots 445,500$ units.

The amount of heat passing off through the glass ceiling will be—

$C = 3 \times 1,000\ (113 - 59) = \ldots\ldots\ldots\ldots 162,000$ units.

The amount of heat to be developed within the double roof = $\ldots\ldots\ldots\ldots 607,500$ units.

Admitting that the coke stoves employed utilize, as is almost always the case under similar circumstances, 90 per cent. of the heat given out by the fuel, and that a pound of coke produces 12,600 units of heat, it is necessary to burn every hour $\frac{607,500}{0{\cdot}90 \times 12,600} = 53{\cdot}57$ pounds of coke an hour to prevent, under these almost extreme conditions of cold in Paris, the glass from cooling the room beyond 59°. At evening receptions, the lighting up of the room requiring a burner consuming $3\frac{1}{2}$ cubic feet of gas an hour to every three square feet of floor area, the heat produced will always be more than sufficient to prevent the cooling of the interior.

The preceding figures show why most makers of heating apparatus who have undertaken to warm halls or courts covered by skylights have only very imperfectly succeeded.

DWELLING HOUSES.

103. Among the appendages of dwelling houses which most often give out disagreeable smells should be placed, in the first rank, yards, kitchens, and privies. In consequence of the draught exerted by the chimneys of rooms near these places, it often happens that at certain times more or less infectious air is drawn into the apartments.

To avoid this serious trouble, it is necessary, by means of proper arrangements, which should also be simple, to produce a regular and almost constant motion of air from the apartments or the halls toward these places, discharging from them to the exterior. This may be accomplished in several ways.

104. *Court yards of dwelling houses.*—Apartment houses, especially in Paris, very often contain little yards, belonging to the stores on the ground floor, which seriously affect the healthfulness of the upper stories. Provision stores, restaurants, dye houses, drug stores, etc., give rise to disagreeable or injurious smells, which rise and annoy the occupants of the house and injure the property.

These disagreeable effects may easily be overcome in the following way: The yard should be covered, in whole or in part, with a glass roof, forming a single inclined plane between the ground floor and the second story. In an angle, and at the upper part of this roof, should be placed a chimney, extending above the upper cornice, the section of which should be calculated so that with a velocity of about three feet a second the air of the court yard will be renewed once, or, better, twice an hour.

At the lower part of this chimney should be placed a gas burner, consuming only $3\frac{1}{2}$ cubic feet an hour. The velocity being small and the chimney high, about 1,800 or 2,000 cubic feet of air may be carried off in an hour by this chimney to every cubic foot of gas burned, and thus a constant purification of the yards be secured.

When local arrangements favor, it will only be necessary, in order to keep up the draught, to carry a smoke pipe up the chimney, or to start a fire in a coke stove placed in it.

105. *Kitchens.*—When ranges with hot-air passages, such as are now in general use, are employed, it will be easy when they are put up to place hot-water pipes around the grate, and carry them a certain distance up the chimney and back to the range, as in the boilers of hot water heating apparatus, which would secure a sufficient draught.

106. *Use of gas burners for the ventilation of kitchens.*—In kitchens lighted by gas, when the ranges are already put up in the usual way, lighting one or two gas burners at the bottom of the chimney, to be kept burning only while cooking is going on, would in most cases suffice to produce a draught sufficient to carry off all smell.

Example.—The kitchen for a single flat in Paris is considered quite large if 10 feet long, 13 feet wide, and $11\frac{1}{2}$ feet high; that is, with a content of 1,490 cubic feet.

It follows from direct experiment that, with the aid of a single gas burner, consuming $1\frac{1}{2}$ feet an hour, and kept burning only while the meals are being prepared, that is to say, at most six hours a day, there may be produced every hour, with sheet iron ventilating pipes $9\frac{1}{2}$ inches in diameter, and

52	39	33	26 feet high,
1,780	1,475	1,407	1,257 cubic feet,

the renewal of which, added to the natural ventilation produced by the kitchen fire, will fully suffice to change the air of such a kitchen more than once an hour.

The expense for a whole year for one small gas burner, consuming $1\frac{1}{2}$ feet of gas an hour, and burning six hours a day, would be $8\frac{1}{2}$ cubic feet a day, or 3,100 cubic feet a year, which, at the rate of $1.70 a thousand feet, would cost $5.27, a very moderate expenditure for getting rid of a nauseous smell, which would otherwise be experienced twice a day.

It may be added that the preceding results relate to metal pipes placed on the outside and exposed to cooling, while, in general, similar ventilating pipes may be, and ought to be, made of earthenware, and placed in the thickness of the walls or in the interior of buildings which, exposing them less to cooling, would increase the effect obtained. In the case of large kitchens with wide fire-places, when the ranges are kept very hot, and are used almost all the time, it would be more economical to place a coal grate in the lower part of the chimney, at about the top of the fire-place, and this would also be the most simple and direct method for country houses.

107. *Use of the lost heat from kitchen ranges for ventilating and for heating baths.*—Besides the advantage of securing a change of air and the removal of bad odors from the kitchen, the hot-water pipes mentioned in § 105 serve to supply baths, which may be established with success, as mentioned in § 81, in barracks, as well as in those establishments where provisions are cooked for the poor, to be distributed to them gratuitously or sold to them at a low price. The addition of hot water baths to these useful establishments might thus be made at very little expense.

An arrangement of this kind is adopted with success in the new lying-in house established by the administration of public assistance, Rue du Faubourg St. Jacques, to utilize the lost heat from the stoves used for making plasters.

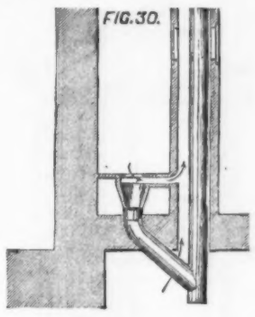
108. The baths may be heated also by means of ordinary hot air kitchen ranges without recourse to the use of hot water circulation, or, what is better, by combining the two means of utilizing the heat lost from the range during the time the meals are being prepared.

109. *Privies.*—The necessary arrangements to be made in order to prevent the infection which these attachments to buildings often produce vary with the mode of construction adopted and the nature of the building.

The regulations for the construction of privy wells are as follows: The down-pipes should dip at their lower end into the contents of the well, or better, into a fixed or movable copper basin, into which it is well when it can be done to force water from time to time in order to wash it.

It follows from these arrangements that the only gases which can ascend in these pipes arise from their internal surface or at the bottom of the pipes, and will not be very abundant (Fig. 30).

FIG. 30.



To prevent the gases from spreading to the interior of the rooms, water-closets called English closets are usually employed within dwellings. In less particular houses and in public establishments, there is simply placed under the opening a basin called Roger Mothe's apparatus, which tips and empties itself by the weight of the contents alone, and then returns and closes the opening.

These convenient means are not always sufficient to prevent the introduction of bad smells on account of small cracks in the joints of the apparatus.

In all cases it is better to keep the seat $1\frac{1}{2}$ or 2 inches above the upper edge of the bowl, letting the front and the two sides reach to the seat and to connect this space with a ventilating pipe extending above the roof.

If this pipe can be placed near a source of regular heat, such as the kitchen flue, or if hot-water pipes can be carried into it, as in the case of mansions heated by hot water, it would be easy to obtain a sufficiently powerful draught in this pipe.

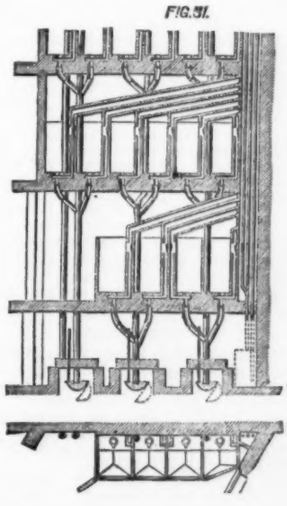
But if this method is not available, as often is the case in small dwellings, the same effect may be secured by placing in the pipe a small gas burner, burning at most 1 or $1\frac{1}{2}$ cubic feet an hour, and which, by the aid of a transom, will illuminate the closet at the same time that it purifies it. A common lamp might even be made use of, burning half or three quarters of an ounce of oil an hour (about one thirty-sixth to one twenty-fourth of a pint).

The ventilating-pipe should be about from 46 to 62 square inches in area, and the small burner, burning $1\frac{1}{2}$ cubic feet an hour, would, in most cases, secure the renewal of 1,000 cubic feet of air an hour, which would suffice not only to expel all the gases coming from the seat and its descending pipe, but even to renew the air of the room several times an hour by drawing in that of the surrounding corridors and also prevent the infection of the interior of the house.

110. *Example—Office of the Northern Railroad Company* (Fig. 31).—If, instead of English water-closets, only open seats are used, or even those called Turkish seats, similar arrangements would produce the same results.

Fig. 31 shows the plan adopted with success in the office of the Northern Railway Company, where there are in the

FIG. 31.



five stories twenty-seven water-closets. The down-pipes serve for all the pairs of seats in each story, and are only three in number. They are 9 inches in diameter, and terminate in the movable copper water-basins, which form siphon traps and prevent the rising of the gas from the well.

All the ventilating pipes from the seats are 4 inches by 16 inches inside. They terminate in a large vertical collecting-pipe, about 10 square feet in sectional area, serving as a ventilating chimney, in which are placed vertical hot-water pipes, which in winter produce a general draught. In summer, when the heating is interrupted, the draught is produced by gas-burners kept burning in each closet.

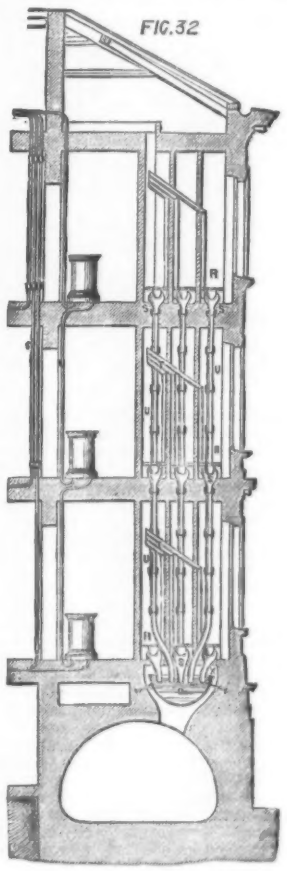
Ventilation by means of hot water circulation can evidently be kept up in summer by means of a separate fire for this special purpose, which would be more economical than the use of gas.

The result of experiments made in February, 1863, was that the amount of air removed for each seat under the action of the draught, produced simply by excess of 7° to 13° of temperature in the chimney over that of the external air, was more than 2,200 cubic feet an hour.

Although much greater than is generally necessary, this amount would not seem excessive in similar cases where, in addition to the seats, urinals, often imperfectly rinsed, are used.

111. *Arrangement adopted at Lariboisière Hospital* (Fig. 32).—In this establishment, the closets on each floor contain

FIG. 32.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119. *Introduction of air.*—But it is not sufficient merely to secure the discharge of the foul air; it is necessary to provide for the admission of an equal amount of fresh air at a proper temperature.

This air, which in winter should be warmed to a temperature of about 68°, may be admitted through an interjoist in the balcony, which is twenty feet above the floor. It should flow horizontally below the chandeliers, above and away from the occupants, and its horizontal velocity of admission may, without inconvenience, be three feet a second. Its volume being 954,000 cubic feet an hour, or 265 cubic feet a second, the total sectional area of the interjoist and of the conducting passages should be 81 square feet.

The length around the inner edge of the balcony being about 200 feet, it will suffice to give the openings—

$$\frac{81}{200} = 0{\cdot}4 \text{ foot of clear height,}$$

but on account of the ornaments which break up the passage it will be necessary to make them 10 inches either in height or in developed profile.

These arrangements will insure the renewal of 954,000 cubic feet of air an hour, or 1,590 cubic feet to each person, if there are 600 present, sufficient in all seasons to secure the healthful condition of the room and to moderate its temperature; but it is not necessary that they be isolated and confined to one of the reception-rooms of the palace. It will be equally necessary to adopt similar arrangements for the two adjoining rooms, which often contain many persons, and also for the large gallery, frequently used as a ball room. It may not be unnecessary to add that for evening parties the two large fire-places which are in the grand gallery may, by means of gas-burners placed within them, serve as ventilating-chimneys; and if there is any difficulty in cutting in the side-walls descending flues leading to the basement, ascending flues may be made separate, or communicating with a single ventilator placed in the roof over each room.

The fresh air should enter above the cornice and in a horizontal direction.

Each of the principal saloons in the palace should thus have its own ventilators provided with regulating-valves; they should be independent of the others, and this will prevent the unpleasant currents which would otherwise arise as the guests take their departure.

(*To be continued.*)

RECENT WONDERS OF ELECTRICITY.*

By W. H. PREECE, F.R.S.

Lecture II.—Delivered on Wednesday evening, January 4, 1882.

LAST week, when we had the pleasure of meeting, I endeavored to disabuse your minds of any such idea as that electricity was a fluid, or, in fact any kind of matter. I pointed out to you that every electric phenomenon really was a form of that curious, mysterious agency that exists throughout nature, that produces all the work done on the face of the earth, that probably is at the foot of life itself, called energy. Nevertheless, we can speak of electricity as though it were a distinct entity, precisely in the same way that we speak of sound, of light, and of heat. We know that sound and heat are not sensible to the touch, or taste, or sight; so electricity is of the same character, and is invisible and insensible in every shape or form. Moreover, we cannot either create or produce energy; there is only a certain fixed quantity of energy in the universe, and all that we can do is simply to transform it into its different shapes, such as I illustrated to you last week. All physical phenomena, without a single exception, may be traced to the mere transformation of this energy. I showed you on the last occasion how, by simply winding a wire round a mass of iron, and sending a current of electricity through the wire, we could produce that form of energy called electro-magnetism. To-night I have to speak of one or two other forms in which this energy does its work, forms in which, when electricity is transferred through matter, it does work in some shape or another. The operation of the electric current, when passed through chemical compounds in solution or liquid, is to tear asunder the constituents of the compound, and to arrange them on different sides. A simple means of illustrating this is a glass jar, like the one before you, containing water and two glass tubes, each fitted with a stop cock. When an electric current is passed through the water, the elements of water, oxygen and hydrogen, are driven asunder, and take refuge, as it were, in the right or left hand tube respectively. To prove that these gases have been collected, if a lighted match be placed over the hydrogen tap, the hydrogen will give evidence of its presence by by inflammability; but if the match be blown out and immediately presented to the tap of the tube containing the oxygen, that gas will make its presence evident by relighting the match. [Experiment shown.] The effect of the passage of electricity through water is something like the effect which would be produced by a storm, or other agency, in this room, which caused all the boys of this audience to go to one side, and all the girls to go to the other—excepting that in water there are always two parts of hydrogen to one part or volume of oxygen. Not only does the current tear asunder the oxygen and hydrogen of water, but it also breaks up the constituents of most of the chemical compounds, and the weight of material decomposed per second is the exact measure of the work done and of the current flowing. For instance, if we take a solution of sulphate of copper and pass electricity through it, the solution is broken up into copper and sulphuric acid, and if a bunch of keys were put into the solution while the electricity was passing through it, the keys would receive a deposit of copper. If nitrate of silver solution were used instead of the sulphate of copper solution, silver would be deposited upon the keys or piece of metal inserted. Through the kindness of Mr. Bolas, I am able to show you an experiment of this kind, which will enable me to give you a record of this evening's entertainment. I have here a large glass dish containing a liquid, which no doubt appears to you like water, but which is really a solution of the double salt of cyanide of silver and potassium. In this solution I now place a piece of sheet copper, which you see has the usual appearance of copper all over it. Now, while that plate of copper is inserted to one-half its extent in water, we will pass electric currents through the liquid from the hand dynamo-machine on the table [experiment proceeding], which cause the cyanide of silver to break up into cyanogen on one side and silver on the other, and if I take out the plate of copper, you see there has been deposited upon its immersed surface a coating of silver. Silver spoons and all the various kinds of electro-plate wares receive their silver deposit in the manner I have just shown you. Now, we will set this small dynamo-machine in action by turning its handle, thus converting the energy of the human body into electric energy; and we will immerse a quantity of brass buttons in the liquid, which, when they have received their coating of silver, will be laid aside, ready for distribution as a memento at the close of the lecture. Through the kindness of Messrs. Elkington, I am able to show you the handsome specimens of electro-plating which hang on the walls of the room, and which were plated at their works at Birmingham, by a process exactly similar in character to that I have described, excepting that steam power is substituted for the manual labor you just saw for producing the electric currents.

We next come to the work performed by electricity in passing through solids. The result of that work is simply the production of heat. Before me you will notice two brass stands, and between them I will suspend a piece of fine platinum wire. I now join up one of my battery wires (the same that I used last week) to one of the brass stands, and touch the other brass stand with the other battery wire; the effect appears as a red glow in the platinum wire. If I bring one of my battery wires from the bottom of the brass stand to the end of the platinum wire, the color of the glow becomes brighter; and as I move my battery wire along the platinum wire the glow or light produced by the high temperature in the platinum becomes more and more intense, until finally, when it reaches a certain temperature (about 3,000° Fahr.) the wire is ruptured and falls to the ground. That is evidence that the passage of electricity, through solid conductors, produces heat, and the amount of heat produced is proportioned to the work done in the battery. Energy expended in one part of a circuit must be given out at another. If zinc is consumed in a battery, it generates a certain amount of energy; that energy must be evident in some other part of the circuit, and the heat you saw in the platinum was really the heat that would have appeared in the battery itself if we had not caused the current to flow through a solid conductor which offered a considerable amount of resistance to its progress, as compared with the resistance in the battery itself. This power of producing heat has been utilized in various ways, such as for firing fuses. [An Abel fuse was exploded.] At many places throughout the country, time guns are fired by such an electric fuse to announce the Greenwich-time current at a certain hour. Mines and torpedoes are exploded in a similar manner; quarries are blasted, and many other results are brought about by passing electricity through platinum wire placed in explosive substances, or by special fuses. I do not intend to frighten or alarm you, but for your amusement, and through the kindness of Professor Abel, I have had fuses fixed out of harm's way at various points round the room, and when a small current is passed through them you will hear the explosion produced. [Experiment carried out.] Those fuses might have been fixed miles away, and the same effect would have been produced, and from it you will understand how a number of charges can be fired, or a number of guns can be discharged simultaneously on board our large men-of-war.

The next branch of the subject is the work done by electricity in its passage through air and gases. I have shown you that, in its passage through liquids, it tears the constituents of the solution asunder; in its passage through solids heat is produced; and in its passage through air, it not only produces heat, but violent projection of material particles as well, which it renders incandescent, producing sparks, heat, and other disruptive effects. To illustrate this I have provided an Apps induction coil, to which can be joined up vacuum tubes of various kinds, and through which the currents produced by the hand dynamo-machine will be passed. [A beautiful collection of vacuum tubes, fitted with various rarefied gases, was then shown, while the lights were turned down.] In those effects we have the result of electricity passing through air, and gases of extreme tenuity, and also an indication of the way in which electricity produces heat—and, therefore, light—in gaseous matter. All instances of artificial lighting or heating are simply due to the fact that we are able to produce heat, and heat of a very high temperature. It is a curious fact that all matter, whether metal or porcelain, carbon or lime, begins to emit light at precisely the same temperature, which closely approaches 1,000° Fahr., or, to be accurate, I believe it is 980° Fahr., so that whenever it is possible by any means to raise any material to that temperature, light is emitted, and the intensity of light increases, until, in the case of carbon, when about 4,000° Fahr. is reached, the material is destroyed. In platinum a lower figure (3,082°) represents the point of fusion. To obtain this very high temperature by electric currents, we must utilize higher means of producing the electricity than I have hitherto shown you. In the battery I have just used, the electric current was produced by the combustion of zinc, but now I want to explain to you how, as I said, muscular power was converted into electric energy. The reason is simply due to the fact discovered by Faraday, that whenever a wire or conductor moved through the sphere or field of a magnet it became electrified. I take up the brass rod before me and move it rapidly, and by doing so have to a certain extent electrified it by causing it to pass through the magnetic field of the earth. The earth is an enormous magnet, a fact which we know, because our compasses guide the mariners across the deep. The air in this room is under the influence of the earth's magnetism, and if I move a wire or rod within that influence, at right angles to the lines of magnetic force, I cause it to be electrified, but only to an excessively small extent. The strength of the current produced depends upon the strength of the magnetic field, and upon the velocity with which the conductor moves across the field. Instead of having only one rod or one wire, we have in this hand-machine an arrangement of a thousand turns of wire; instead of having the weak magnetism of the earth, we have the powerful field of permanent magnet; and instead of causing it to move through the air by the velocity of my arm, we apply multiplying gear, which, as you see, imparts velocity to it of great rapidity. Thus motion, through a magnetic field, produces an electromotive force. There never can be a continuous electromotive force without some source of energy. Here we have mechanical energy expended, and all the conditions for the production and maintenance of a current. Energy expended in one point must be found in some form in another point. If it is not utilized it is wasted. Some of it must always be wasted, and the true economist will try and waste the least possible quantity. If I place a piece of platinum wire between the two wires connected with the hand dynamo-machine, you see that the muscular energy of my assistant, by turning the handle, generates currents of electricity, which give a red heat to the platinum wire. The energy of the body is thrown into the machine, the machine converts it into electricity, the electricity passes through the wire, which, by having work done upon it, is rendered incandescent, and in consequence becomes luminous. I have here a lamp containing a piece of platinum wire, and if I connect it to the wires of the dynamo-machine [this was done], the platinum glows and gives us light. It is a machine precisely similar in principle to the one now before you, fixed under the arches on the Thames Embankment, and worked by a steam-engine (lent for the purpose by Messrs. Robey), that is supplying currents of electricity to the lamps now lighting this room. There is an occasional throb in the light; this is produced by the unsteadiness of the engine, which was not specially prepared for the purpose, but was the best available. It is in fact an agricultural machine. There are two kinds of electric machines of this class. One is called the magneto-machine, like the one before you, because the magnetic field is produced by the presence of a powerful permanent magnet which I think is visible to most of you, and which consists of several pieces of steel that have been magnetized. The other kind of machine is called the dynamo-machine, in which the magnetic field is produced by an electro-magnet, which is itself excited by the currents it generates, so that there is a kind of accumulative action: one current piles up the agony on the other current, and all of them together, acting on the electro-magnet, increase the total effects until the iron is saturated with magnetism. So much as regards the production of currents for electric lighting purposes. The motion of the conductor through the magnetic field may be caused by the energy of coal which is consumed to generate heat and steam for working a steam-engine; or, as at Godalming, by the energy of water on a water-wheel; and it is very probable that where water is available, it will be the most economical source of energy for electric lighting purposes. Sir William Armstrong, at his seat at Craigside, near Newcastle-on-Tyne, has illuminated his house for some time by currents of electricity, produced by a waterfall in his grounds, so that, he says, his library and his drawing-room are lit by the river flowing through his grounds. As regards the light itself, there are two kinds of lamps. I have already explained and illustrated to you the fact that electricity in its passage through air produces sparks. I have here what is called an arc lamp; in it two rods of carbon are held by two brass clips (not in metallic connection with each other), and the ends of the carbon are, when in action, a short distance apart. On joining up the wires to the brass clips the current flows, a bright light is instantly set up in the air between the carbon points, and the arc is formed. This light is due to the passage of an infinitely rapid succession of particles of carbon, which are projected across the air space, which, in their high state of incandescence, produce light, and which in brilliancy would not compare unfavorably with that of the sun. The light from a larger arc lamp would be far more brilliant than this, but I do not want to damage your eyes or my own. I have experimented on the electric light so much, that I have suffered great tortures from the irritating and exciting influence of its bright rays upon the retina of the eyes, and I advise all people who have an opportunity of examining the arc light, not to look at it too much, or the eyesight may be unfavorably affected. The arc light is used principally for lighting large areas, for instance, Charing Cross station is lit by one form of arc light, called the Brush; Cannon Street station is lit by what is known as the Brockie lamp; the space in front of the Royal Exchange is lit up by the Siemens arc lamp; King's Cross station is lit up by the Crompton plan; and so on. A very brilliant arc lamp at Paris, which attracted a great deal of attention, was called the Jasper light. But all arc lamps play upon one string, similar to the plan I have just shown, viz., that when two pieces of carbon are maintained at a certain distance from each other, and electricity passed between them, great heat and brilliant light is the result. There are certain difficulties in arc lamps which militate against their employment for domestic and internal use generally. The light is very intense; the effect is irritating; the ladies do not like it (and they are a powerful influence in this country), because it does not suit their complexion nor the style of costume for evening wear; they have set their faces against it for internal illumination, and that being so, it is all up with it. Now, the light that is going to supplant the arc light for domestic purposes is the incandescent light. The principle of the incandescent lamp is exactly the same as that I showed you in Mr. Becker's lamp, viz., that a suitable substance is inclosed in a glass bulb from which the air has been extracted, and is brought to a high state of temperature by the passage through it of currents of electricity. The lamps illuminating this room are Mr. Edison's incandescent lamps, whose representative, Mr. Johnson, has been most indefatigable in his assistance for these lectures. The Edison lamp consists of a single curl, or loop, of a fine carbon filament (instead of platinum wire) placed in an exhausted glass bulb. The carbon is extremely thin—as thin as a human hair—but, in spite of its extreme tenuity, you see [knocking a lamp on the table] that concussion or shaking does not cause it to break, but it possesses great resilience, and vibrates like a steel spring; and it is so refractory that it will stand electric currents of enormous strength. As I have said, the lamps before you are worked by electric currents generated by an Edison dynamo-machine on the Thames Embankment but each lamp is self-regulating and (you see) can be turned on and off by turning a tap very like those used on gas brackets. The stronger the current supplied to the lamp, the greater its heat and brilliancy, and when, by turning a handle in the instrument I have for the purpose, the strength of the current is increased, it forms a brilliant light in the glass tube, until the amount of current is greater than the carbon can stand, when it radiates a beautiful blue haze, which indicates that its end is near, and then it is broken (as you see) and the lamp goes out. I can easily replace the broken lamp by unscrewing it out of its socket, and placing a fresh one in its place, when at once all is in good order, and the light resumed. These lamps are water-tight as well as air-tight, and to prove this, I will insert a lighted lamp into the little aquarium on the table, when you see that the globe is brilliantly lit up, and that the fish it contains show rather a sign of curiosity than discomfiture, and seem rather proud of their colors, which are so distinctly brought out by the brilliancy of the light. Here I have a globe of colored water, to show what brilliant effects can be produced. A good deal has been said about the dangers of electric lighting, and how careful we ought to be in its use, and there is no doubt that electricity is a very dangerous agent if you do not know how to use it. We have heard of the danger from fire through its use in theaters and houses, but I want to show you that, when I place a cambric pocket handkerchief round a lamp, which I then break while electricity is going through it, no

* Two lectures delivered before the Society of Arts, London. Lecture I. in SUPPLEMENT, No. 327.

spark or fire of any kind occurs, but the lamp instantly goes out. [Experiment shown.] There is also danger from wires coming in contact with each other, and in that case they short circuit the machine; they cause an increased strength of current to flow, producing heat, and in that manner setting fire to houses. To obviate this danger "safety catches" have been introduced by Mr. Edison. These safety catches consist in the insertion of a very small piece of lead wire in the circuit, which is readily fusible, so that if the current becomes unnecessarily powerful, it passes through the lead wire, heats it to fusing point, and so breaks down the section on which the "safety catch" is placed, eliminating at once all danger. [Illustrated.] It does not affect any other lamps, as you see. When the fused safety-catch is replaced by a good one, the lamps which were broken down by its rupture become lighted up again. We have the means of regulating the lights now burning in the room. Here is an apparatus in connection with the machine at the engine station, and by moving the handle and inserting in the circuit a certain amount of resistance, I am able so to reduce the current flowing from the machine that a considerable lowering of the light takes place. On turning the handle back again, the former brilliancy returns. That shows the electric light in the latest stage of its perfection. We have a bright light now in this room, but no impure gases are given off by the electric light, and the air is not vitiated by it. The room is warm, but that warmth is due to the number of people present, and not to the heat produced by the electric light; though the electric light does, as I have said, generate heat to produce its effulgence. Many people talk of the electric light as being "cold" and cheerless. The light produced by the arc lamp does look cold and cheerless; but the soft, delicious, incandescent lamp before you has just as soothing an effect upon the eye as the prettiest lamps or the pleasantest candle; and it has certainly removed all the objections that were previously raised to the electric light for internal illuminating purposes.

The next and last branch of my subject is the transmission of motive power to a distance. I have shown you how currents of electricity are produced; also how they do work; how they produce electro-magnetism; how they generate heat; how they produce light; and now I want to show you that the whole thing is reversible. If, by the exertion of mechanical power, currents of electricity can be produced, those very same currents of electricity can in their turn produce mechanical power. If instead of receiving currents of electricity from the dynamo machine on the Thames Embankment, we transmitted currents of electricity to it, we should cause it to rotate, but in the reverse direction. I have here a small machine for the purpose of illustrating this to you; it is the invention of Mr. Griscom, who has supplied it to a large extent in America for turning sewing machines. The wires from the hand dynamo-machine are now attached to the Griscom motor, and when currents of electricity are generated by turning the handle of the dynamo, they are conveyed to the motor, and cause it to revolve with the high rapidity which you see. It is surprising that such a tremendous momentum should be produced by so small a strength of electric current. The wires connecting the two machines in this instance are short, but the effect would have been practically the same had the machines been miles apart. By changing the wires, the direction in which the motor rotates is reversed, so that I not only get power transmitted, but can reverse its direction. In this case, as the electricity is generated by hand, its power is small; and, therefore, with my strength (which is only about one-twelfth of a horse power) I can stop the rotation of the motor; but if steam power were employed to generate the electricity, the power transmitted would be beyond my control, in that sense. This motive-power was illustrated in many different forms, at the Paris Exhibition; for instance, from the commencement of the Champs Elysées to the Exhibition Building, a tramcar was propelled (sometimes at the rate of 25 miles an hour) upon rails laid down for the purpose, and during the time that the Exhibition was open, that car carried 75,000 to 80,000 people, who were conveyed to or from the building by motive power, generated by steam in the Exhibition, and conveyed by wires to the farther extremity of the track. An electric railway will form part of the Electric Exhibition at the Crystal Palace, and among the proposals to be laid before parliament next session is a project for constructing an electric railway between Northumberland Avenue and Waterloo Station. Again, at the Paris Exhibition, an enterprising firm of agriculturists showed land-plowing by electricity, and in fact, the application of electricity to innumerable useful purposes was illustrated; rock boring, newspaper printing, driving of sewing-machines, embroidery, leather work, glass cutting, wood carving, lifts raised, ventilation assisted, etc. I am looking forward to the Crystal Palace Exhibition with great interest, to see how far these exhibits will be repeated. The exhibition will be well worth a visit; in fact, all exhibitions are worth visiting, for they excite interest, they induce every one, more or less, by generating curiosity, to add to his knowledge; they honestly stimulate national as well as individual competition; and they always result in the enlargement of the useful application of a power like that of electricity, because a man of one trade who sees electricity used in another trade cannot resist thinking out whether it cannot also be usefully applied to his own purposes. We sometimes hear electricity spoken of as a mysterious agency, and sometimes as a wild, untamed beast. It is only mysterious to the ignorant, and it is only untamed to the unskilled. I hope that the promise I made to you at first starting, that you would leave this room with a fair knowledge of how the electric light is produced, has been fulfilled, and I can only add that electricity will always prove an obedient slave to those who take the trouble to understand it; but it may, as it has, proved a very dangerous ally to the ignorant and the unskilled.

A hearty vote of thanks was accorded to Mr. Preece for his two lectures.

NEW TREATMENT OF DISTILLERY REFUSE.

THE weak liquors which escape from the distilleries injure the water of streams and springs, and in some cases become a medium of infection for the whole neighborhood. MM. Gaillet and Huet add to the liquors perchloride of iron in suitable proportion, mixing the ingredients thoroughly. After the first reaction is completed milk of lime is stirred in, which precipitates the sesquioxide of iron, carrying with it almost all the organic matter. The remaining liquid is perfectly clear, colorless, harmless, not liable to fermentation, and offering no inconvenience to the public health. The precipitate forms a manure, very rich in nitrogen and in phosphoric acid. The sale of the manure not only frees the refuse from being a burden upon the industry, but also makes it a source of profit.—*Les Mondes.*

THE RECTIFICATION AND DISINFECTION OF IMPURE ALCOHOLS ACCORDING TO THE METHODS OF L. NAUDIN, R. PICTET, AND EISENMANN.*

Report of M. A. SCHLUMBERGER.

I HAVE the honor to submit to you the report which you intrusted me to make on the rectification of badly tasting alcohols by the methods which have been submitted to you by L. Naudin, Raoul Pictet, and Eisenmann.

The extreme importance of this problem of the rectification of alcohols in general has caused me to divide in two distinct parts the essay which I lay before you; I shall especially insist on the hygienic side of the question, for I believe that it is necessary, above all, to consider this subject from the standpoint of the public health.

We should, without hesitation, join those innovators who by all and every means succeed in ameliorating, or rendering wholesome, the substances necessary to life.

It is evident that if alcohol did not exist we should not experience the abuses made of this liquid, but since our mission is not to prevent the consumption of alcoholic liquids, it is our duty to encourage the use of those means by which we succeed in purifying these kinds of beverages, and in rendering them more wholesome, so that the consumers may make use of them with more guarantee against the effect that a prolonged usage might exercise on their health.

The highly interesting experiments of Messrs. Dujardin-Beaumetz and Audigé, Rabiteau, Is. Pierre, Albertoni, and Lussana, called attention to the causes of the insalubrity attributable to the majority of those alcohols of which the rectification has been imperfect.

As long as our noble vineyards of the South and of Charentes prospered, the reputation of the brandies of France was such that it was not necessary to make use of alcohols made from beets, grains, or potatoes; the impure alcohols served almost exclusively for the uses of industry; for the fabrication of aniline, for dying, the extraction of alkaloids, etc., etc.

To-day, unfortunately, the situation, if not reversed, is at least considerably modified; the phyiloxera depriving us of a great part of our vintage products, industry has been obliged to supplement the deficit. The North is destined to give us what the South has no longer; the alcohols of grains, of beets, and of potatoes, have become very important objects of consumption.

The foreign importation amounts to about 200,000 hectoliters (a hectoliter=100 liters) of alcohol made from Russian grains and German potatoes.

We have an especial interest in France to promote the production of beet alcohol, because the soil of France particularly in the North and West is very favorable to this root.

When one considers the enormous quantities of alcohol which arrive at Montpellier directly from Berlin, and the shiploads of maize which come to us from the United States to be turned into alcohol (so called cognac !), one should, it seems to me, make every effort to put an end to such an abnormal state of things, and to facilitate in France the production of pure tasting alcohol by means of a product of native culture, viz., the beet.

The silotage of the beet which is limited for the fabrication of sugar (because at a certain period the crystallizable sugar becomes decomposed) exerts no influence on the yield in alcohol.

All these favorable circumstances cause us to hope that in a near future the petty farmers of the North and West may become small distillers, and that they will accomplish in that part of France what the distillers of the raw material have done in the South.

But it is evident that the production of beet alcohol will only be of importance when rational methods of disinfection and rectification of the flegmes have become vulgarized.*

The causes of the bad taste of alcohols are the numerous spirits and organic acids of the fatty series; ethelic aldehyd, butylic aldehyd, amylic alcohol, isopropylic alcohol, etc., etc., which one finds equally in the alcohols of inferior quality, constituting above all the base of the toxical elements which render the use of alcoholic drinks of that nature so extremely harmful to health.

The effects of alcohol, so frightful to record, would certainly not be so terrible if one only made use of absolutely pure alcohol such as that of the grape. (It is understood that the absolute purity of alcohol does not exclude the addition of water, without which it would be impossible to drink.)

The separation of impurities from alcohol is extremely difficult; on examination of the fermentations of beets one finds that they are literally infected, and one asks one's self how one can succeed by rectification in making pure alcohol, without bad flavor.

It is impossible by the ordinary methods to separate, even by fractional distillation, ethylic alcohol of a decided taste —when it contains butylic aldehyd, because the boiling points of these two liquids differ only by two or three degrees.

In general, the alcoholic flegmes are a very complex mixture of substances, boiling at different temperatures, and separable only by mechanical means, or in following the physical law that, in rising in a column of rectification, the vapors of a heterogeneous alcohol separate more or less thoroughly, according as they are in a more or less elevated temperature.

The lightest parts continue their upward march of distillation, while those more dense fall in the still.

Animal charcoal, which has been much employed for the disinfection of flegmes, had to be abandoned because it is costly to keep in order, and does more harm than good to the flegmes in this sense, that it generally retains, mechanically, the appreciable parts of badly burnt organic substances which communicate to the flegmes a persistent taste of animal matter in decomposition.

Wood charcoal does not present the grave inconveniences imputable to animal charcoal, but it does not possess a sufficiently decided disinfecting power.

Olive oil, which has been used to disinfect flegmes, dissolves certain bad tasting, volatile principles which have arisen during fermentation, but the results leave much to be desired, since oil beaten with the flegmes ends by becoming rancid at the contact of air and steam, and communicates a bad taste to the products which it was destined to disinfect.

These different modes of disinfection to which I have called your attention, after having conscientiously studied the work of Mr. L. Naudin, are only, properly speaking, mechanical or empirical.

Recourse has been had to chemical means, and one has, so to speak, exhausted the series of oxygenizing substances, chosen because it was believed that one attained the object in burning, or better still in dishydrogenizing the empyreumatical parts; this is an error.

It would take too long to describe here all the methods which have been tried or utilized with the object of obtaining a more or less thorough disinfection of the flegmes. The limited nature of this essay obliges me to discuss only the three methods which I have been charged to examine: that by electrolyzation, that by cold, and that by ozone. In examining, from the standpoint of priority, each of these processes, I arrive at the following classification:

1st. Method of L. Naudin, by electrolyzation.*

2d. Method of Raoul Pictet, by cold and by vacuum.†

3d. Method by Eisenmann, by ozone.‡

I cannot dwell as I should have wished upon a description of the apparatus of the first two patents, because, unfortunately, a fire destroyed, on the 9th of last December, the manufactory of Gaston Boulet, at Bapeaume les Rouen, where 300 hectoliters of alcohol were rectified daily by the electrolyzation method.

This accident prevented me from accepting the proprietor's offer to study the operation on the spot.

Nevertheless, I have taken my information from the best sources, especially from Mr. Paul Shutzenberger, Professor of Chemistry at the College de France, where Naudin made his first experiments; then from Messrs. Benner and Gros Renaud, who were designated by the Industrial Society of Rouen to investigate the value of the Naudin method.

I have also examined the flegmes of maize and beets before and after the action of electrolyzation, and I am convinced of the excellence of the method of this excellent chemist.

The samples which were sent to me from Rouen bore the stamp of the French government which oversees the operations of the establishment of Mr. Boulet; I submit to your examination some of the samples, and you will see that the alcohols obtained from beets by the Naudin method are of absolutely pure taste.

The aldehyds, which are only alcohols dishydrogenated, have been reconstituted in their corresponding alcohols by fresh hydrogen resulting from electrolyzing action, and have by this lost their poisonous properties.

The phenomena of hydrogenation are explained by the following equation:

$$\underset{\text{(Ethelic aldehyd.)}}{C_2H_4O} + \underset{\text{(Hydrogen.)}}{2H} = \underset{\text{(Ethylic alcohol.)}}{C_2H_5OH}$$

It was an important point to succeed in reconstituting, by physico-chemical means, the fractions of alcohol which had lost a part of their hydrogen us a consequence of the different operations of the fermentation, and the concentration of the flegmes. Thus far, it does not appear that any process of disinfection of the flegmes has reunited better than that of Mr. Naudin all the conditions desirable to attain a sufficient purity. The practical yield for the flegmes of beets at 55° is alcohol at 80°, equal in quality to that of alcohols from grain. It is of a pure taste from the first jet.

Permit me here to quote some lines from the excellent notice that Mr. De Parville published in the *Journal des Debats* of Dec. 4, 1881, in a description of the Exhibition of Electricity at Paris. He says:

"Mr. Naudin, having set the electric battery in movement, follows the first operation by a second much more energetic. He passes the flegmes successively in large tubes of glass, in the midst of which are plunged two plates of platina in communication with a Gramme or Siemens dynamic electric battery. The energetic current which traverses the platina plates and flegmes decomposes the water in abundance. The oxygen concentrates on the evil-tasting products and burns them. Probably one thus disposes of those substances which require for transformation an excess of oxygen. Afterwards, a new hydrogenation takes place of those products which require to be saturated with hydrogen. All bad taste is removed, and the beet alcohol becomes equal in quality to the best alcohols made from grain."§

As to the Raoul Pictet method, it appears to deserve especial attention from the standpoint of mechanical division. His method of distillation in a vacuum, and absorption and condensation of vapors by cold, is assuredly very ingenious and merits recommendation. I do not know, however, that this method has been applied on so large a scale as that of Mr. Naudin, and, in any case, the division by cold of liquids of different degrees of density does not accomplish exactly that which the Naudin method does, which possesses, above all, the advantage of transforming the aldehyds into corresponding alcohols; is is evident that one cannot succeed by cold in modifying the chemical conditions of the decomposed fractions in the alcoholic liquid under its influence, and it is desirable, according to my mind, that Mr. R. Pictet should complete the ingenious arrangement of his apparatus by means of a chemical reaction capable of re-establishing the broken equilibrium in the constitution of the elements which form the alcohol.

Mr. R. Pictet has graciously invited me to visit the new establishment which he is constructing to replace that which he established temporarily in the Rue des Immeubles Industriels; I shall, therefore, later, be able to give a more definite decision on the merits of the cold method; I shall also be able to judge better on visiting, after reconstruction, the establishment of Mr. G. Boulet, at Bapeaume.

Before closing, I will merely refer to the ozone method of Mr. Eisenmann. From documents which I have, and which have served me in studying the question from his standpoint, I find that the Eisenmann patent presents absolutely nothing new.

The expired patents of Loew, of July 4, 1881; of Widemann, of Aug. 3, 1872 (especially the last), treated of ozone long before that of Mr. Eisenmann of Berlin.

The conclusion of the Widemann patent indicates this clearly:

"The results of my invention are the application of ozone:

"1st. To the treatment of alcohols to remove their empyreumatical taste.

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* Translated from the *Journal d'Hygiène*, by Charles Howard Young, Membre de la Société Française d'Hygiène de Paris.

† Watery products of the first distillation of the juice of grains, beets, etc. They mark about 40° by the alcoholmeter, and contain, besides alcohol, the essential oils of ether, etc. It is in rectifying the flegmes that one obtains alcohols at 95°.

* Patent of Aug 30, 1879, additions of Nov. 17, 1880, and Jan. 27, 1881.

† Patent of July 24, 1880, and April 15, 1881.

‡ Patent of July 26, 1881.

§ Mr. Naudin has published on this subject a very complete and interesting pamphlet well worthy of consultation. It is entitled "Disinfection of Impure Alcohols by Electrolyzation." Paris: Publisher, Gauthier Villars, 55 quai des Augustins. See the *Journal la Lumière Electrique*, Sept. 1881, article of Mr. Guéront.

"2d. To the bleaching of oils, glycerine, etc.

"3d. To the treatment of oils, to render them siccative.

"4th. To the acetification of alcohols and alcoholic liquors, to transform them into vinegar."

Does not the Eisenmann patent of July 26, 1881, and its addition of Oct. 11, 1881, trespass on the ground of others in claiming a process by ozone and electrolyzation which recalls the prior claims already cited?

The fact is that the good done by ozone to inferior alcohols is more than compensated for later by the production of acetic acid, a phenomenon always produced more or less according to the oxygenizing influence to which the alcohol is submitted.

In conclusion, I propose to you, gentlemen, to give a word of encouragement to the authors of the rectification of alcohol by the cold and electrolyzation methods, and to especially congratulate Mr. Naudin on the important results which he has already obtained in industrial applications.

Paris, Jan. 13, 1882.

SOME OF THE INDUSTRIAL USES OF THE CALCIUM COMPOUNDS.*

By THOMAS BOLAS, F.C.S.

Lecture II.—Delivered November 28, 1881.

LIME.—THE CALCINATION OF THE CARBONATE IN THEORY AND PRACTICE.—INFLUENCE OF FOREIGN BODIES ON THE QUALITY OF THE LIME.—MOST FAVORABLE CONDITIONS FOR THE DECOMPOSITION OF CALCIUM CARBONATE.—CEMENTS AND THEIR USES.—LIME AS A REFRACTORY MATERIAL.—LIME LIGHT.—THE OXYHYDROGEN FURNACE.—LIME MOULDS FOR THE CASTING OF IRON AND STEEL NOTES ON A FEW OF THE INDUSTRIAL AND ECONOMIC USES OF LIME.

JUST a few figures to commence with. The composition of the ordinary carbonate of lime, as represented by chalk, is expressed by the formula:

$$CaCO_3.$$

Ca stands for 40 parts of calcium by weight, C for 12 parts of carbon by weight, and O_3 for three times sixteen, or 48 parts of oxygen. Thus we have:

Calcium	40
Carbon	12
Oxygen	48
	100

These figures when added together make just 100; so that chalk contains 40 per cent. of calcium.

When carbonate of lime is heated to redness under favorable circumstances, the whole of the carbon flies off in company with two-thirds of the oxygen; the gaseous product thus constituted being called carbon dioxide. The whole of the calcium remains behind, united with one-third of the oxygen, this compound being ordinary lime. In symbolic language the decomposition is thus represented:

$$CaCO_3 = CaO + CO_2.$$

These symbols imply that 100 parts by weight of calcium carbonate split up into 56 parts of lime and 44 parts of carbon dioxide. Although the diminution of weight which a limestone undergoes when burned is 44 per cent. or more, as moisture and organic matters are often present, the reduction as regards volume is much less—say some 14 to 25 per cent.

Here is a small fragment of carbonate of lime in the form of marble. You see that the heat of this blow-pipe is directed on it for a few seconds only; but this suffices to effect the decomposition of a considerable proportion of the carbonate, so that when it is placed on a sheet of damp and strongly colored red litmus paper, a vigorous blue coloration is immediately formed round the material. Although the carbonate of lime is so readily decomposed by heat under these circumstances, it is quite possible to expose it to an equally high temperature without decomposition occurring to a notable extent. If carbonate of lime is heated to redness in a closed iron tube, it simply fuses, and on cooling it solidifies to a semi-crystalline mass, like marble. If it is heated under the ordinary atmospheric pressure, the decomposition is extremely slow, unless the carbon dioxide first liberated is removed by some means. This last fact is very well illustrated by an experiment which it will be easy to show you. Here is an iron tube which passes through one of Mr. Fletcher's new gas furnaces for heating tubes, and this tube is packed tolerably full of fragments of marble. In a few minutes the tube will be heated to bright redness, and you will notice that the evolution of carbon dioxide, as measured by the occasional bubbles which pass into the gas jar, is extremely slow. Notice now the effect of passing steam over the heated carbonate of lime. A rapid evolution of carbon dioxide takes place, and the receiving jar is almost immediately filled with the gas. A stream of air, or other gaseous matter, will produce a similar effect, but steam is most notably effective in expediting the decomposition of heated carbonate of lime into lime and carbon dioxide. In a similar way, the decomposition may be facilitated by a reduction of the pressure; as, for example, when the liberated carbon dioxide is continually removed by means of an air-pump.

A very high temperature is not by any means necessary for effecting the thorough decomposition of carbonate of lime; a moderate red heat being quite sufficient, if other conditions are favorable. A moderately rapid current of steam may be considered to reduce the time necessary for the decomposition to one-eighth, and a knowledge of this fact has led some to suppose that a notable advantage is gained by the burning of damp limestone. This supposition seems, however, to be unfounded, as one may readily believe when it is borne in mind that the greater part, if not the whole, of the water must be driven off long before the heat required for effecting the decomposition of the carbonate is reached. It appears, however, an advantage to place water-troughs in the air-ways of the furnaces in which lime is burnt. In connection with this point, it must not be forgotten that such fuels as wood and coal contain a notable portion of hydrogen, and when this burns water is formed.

In some cases, as when the limestone is contaminated with a considerable proportion of clay, sand, oxide of iron, or alkaline bodies, it is desirable to take advantage of every circumstance which can facilitate decomposition, as an elevated temperature would cause a partial vitrifaction of the lime, owing to its chemical union with the above-mentioned foreign bodies. Sometimes it happens that a sudden elevation of temperature will melt the surface only of the lumps of partially-burnt lime, and, as it were, glaze them over, and thus protect them from further decomposition, while in other cases the vitrifaction may occur all through the lumps. This vitrified lime will not slake at all, or will only slake imperfectly; but for all that it may, if finely ground, form an excellent hydraulic lime or cement; or if mixed with a considerable proportion of a rich or "fat" lime, it may confer hydraulic properties on it. If the heat has been insufficient, so that the whole of the carbon dioxide has not been driven off, each lump of lime will include a kernel, containing a large proportion of the orthocarbonate Ca_2CO_4. Such imperfectly burned lime will not slake on the addition of water, if it consists mainly of the orthocarbonate; but if ground and mixed with water, it will slowly set, without having much tendency to crack.

These considerations will indicate the propriety of placing the small lumps of limestone, or the least pure varieties, toward the top of the furnace, or near the edges, while the large lumps of the purer stone may be placed where the heat is likely to be greatest. This remark only applies to a periodical furnace, which is burned out before being recharged. The heat advisable in ordinary cases may range from 700° to 1,000° Centigrade, according to the quality of the stone.

Your attention will next be called to some diagrams of the various classes of lime furnace in use. The drawing which is now projected on the screen represents one of the most primitive lime furnaces, but a form still in actual use. It consists merely of a dome-shaped heap, which is 15 or 18 feet across, and is built up of alternate layers of fuel and limestone, and covered with loam, excepting the extreme top and an opening at the bottom, which leads into a tunnel-shaped channel, leading across the bottom of the heap. Although this primitive lime furnace is very wasteful as regards fuel, there are occasions when it is the most convenient arrangement for burning lime.

The next lantern slide represents a rudimentary shaft furnace, and, in most cases, such a furnace is excavated out of the limestone rock itself. It consists of a cylindrical shaft about 14 feet in diameter and about one and a half times as deep, a small horizontal channel serving to admit air; and a dome of limestone is generally built round about the place where the horizontal channel opens into the shaft, so as to allow an approximately equal distribution of the heat. This form of furnace works very satisfactorily, if carefully managed, and very many of them are in regular use all over the country. Those of you who travel on the South-Eastern Railway toward Woolwich may see one by looking out of the right-hand window of the train, just after it has passed Westcombe Park station. The next slides represent improvements on the simple shaft furnace, a fire-brick lining being introduced, the mouth being somewhat contracted; while methods of inserting sticks of wood, so as to lead the draught equally through the various parts of the mass, are shown. The diagram now before you shows another step in advance, a grate of fire-bars being introduced, and a permanent arch of firestone, or other refractory material, instead of the temporary arch built out of the limestone itself. Many forms of interest must be passed over without consideration, in order that you may be enabled to study those furnaces which are continuous in their action, that is to say, are kept constantly burning, fuel and fresh limestone being added at the top, and the burned lime removed at the lower part, without extinguishing the fire. In the case of the furnace now represented on the screen, you will notice the damping arrangement for stopping the draught at the time of extracting the burned lime, the hot lime being raked into the cooling chambers, which are provided with ventilating shafts, in order to facilitate the operation.

It is probable that a notable future is before the process of burning lime by means of gaseous fuel, generated by such an apparatus as that of Siemens, especially when this method is carried out in conjunction with the principle of the ring-furnace, or annular kiln, next to be described.

The annular kiln will become intelligible to you by a study of the diagram which Mr. Barker will next project on the screen. In kilns of this description the fire-chamber may be regarded as a ring or closed circuit, placed in a horizontal position; but this ring need not be round, it being more usually formed like an oblong with rounded corners. The fire-channel or ring may be regarded as being built up of a number of segments, and a cut-off or damper may be inserted between any two of these segments. Each segment has a direct connection with the main chimney; which can, however, be cut off by means of a metal bell, which drips into a ring-shaped vessel containing sand, a form of joint which is extremely useful in furnace work. Each segment can also be opened so as to admit the external air or limestone; and fuel is added through small holes in the top of the ring-system.

Now imagine that one of the dampers or diaphragms is inserted between two of the segments so as to block the ring at that point, and that the segment on one side of the damper, say the right-hand, is open to the air, while that at the other side is connected with the chimney. If the fire is now lighted at the open segment, the flame or heated air will have to circulate round the ring until it reaches the adjacent segment, or that on the other side of the damper, before it can reach the chimney. Things being allowed to go on, a period is arrived at when the maximum of combustion is seated at a point midway in the circuit, or opposite the damper. When this is the case, the segment where the fire first began is emptied of its lime, and fresh limestone put in; while at the same time the damper is shifted, so as to add this segment to the unburned end of the series, the chimney being then connected with it, and the air-way of the next segment on the right is opened. By proceeding in this way, the point of maximum combustion can be kept nearly opposite the diaphragm, or damper, and that air which actuates the furnace becomes considerably heated in its passage over that lime which is already burned, while the waste gases impart a considerable proportion of their waste heat to that material which has not yet commenced to burn.

The waste of heat is so small in a well constructed annular kiln, that in some cases as little as seven per cent. of fuel is used; and, moreover, the labor involved in working the furnace is not very considerable. Several thousand furnaces are in use at the present time, and whenever the operation of lime or cement burning is performed on a large scale, it is likely that this system will come into use, either with solid or with gaseous fuel. It is not at all necessary that the shaft or chimney should be built in the middle of the ring system, as represented in the diagram now on the screen; only when it is outside, some of the chimney channels must be a little longer.

If one wishes to increase the turnout of a ring-furnace, it is merely necessary to use two dampers, and keep each half of the furnace in independent action, but in such a case the air passes over a less length of finished lime, and the products of combustion are less perfectly denuded of their surplus heat, by reason of the shorter length of unburned material over which they pass; there is, therefore, less economy of fuel than when one fire is kept burning in each furnace. If the ring, or annular channel, is made long enough, there is no reason why several fires should not be kept in circulation.

Well, now, lime is a compound of oxygen and calcium; but besides this normal oxide of calcium there is another oxide which contains double the proportion of oxygen. This is, however, a very unstable body, which is of no particular interest out of the laboratory.

One of the most notable properties of lime is its extreme power of resisting the fusing action of fire, the intense heat of the electric arc only serving slightly to soften it. This infusibility is taken advantage of in the lime furnace of Deville; this apparatus being used for melting platinum and other highly infusible metals. Here is a small one which will serve for melting half an ounce of platinum. The metal is placed in the hollow of the lower block, and the flame of a powerful oxyhydrogen blow-pipe is made to enter at the top, as you now see. You notice how the incandescent lime glows, this glow being the well-known lime light. Here is one of the usual arrangements for producing this light. A jet of coal gas is crossed by a fine stream of oxygen, and the sharp and bluish flame is allowed to impinge on a small cylinder of quick-lime; this becoming incandescent almost immediately, and giving out the brilliant light which you now see. The lime light is being used in this magic-lantern for projecting the photographic reductions of diagrams on the screen; and as the light in question is highly actinic, it is of frequent use in many photographic operations, and notably in making enlargements. It is very probable that, before long, the lime-light may compete with the electric light for the illumination of large buildings and open places.

Iron and steel may be satisfactorily cast in lime moulds. Here are some specimens which were poured into the moulds just at the commencement of the lecture, and if you will pass them round you can try them with this file. Certain continental engineering firms make considerable use of lime moulds for steel, and these moulds may either be cut out of blocks of lime, or they may be made, like ordinary moulds, out of a mixture of tar varnish and powdered lime. In any case they should be heated to a low red heat before the metal is poured in.

The Gilchrist-Thomas process for the dephosphorization of iron is well known to you; the converter being lined with lime bricks, which take up the phosphorus during the operation of "blowing." One of the bricks used is on the table, and you can examine it for yourselves. It is coated externally with pitch as a protection against the atmosphere.

When lime is brought into contact with water, combination soon ensues, and heat is evolved; a white powder containing CaH_2O_2, and commonly known as slaked lime, being the result. The heat evolved by the slaking of lime has been known to cause fires, and one occasionally sees workmen cooking breakfast or dinner by the heat of a heap of slaking lime.

When lime is freely exposed to the air, it soon absorbs enough water to become slaked, but at the same time it absorbs carbonic anhydride, and is partially converted into orthocarbonate, $Ca_2CO_4 + xH_2O$, a substance which is excellently well adapted for making mortar.

Lime dissolves in about 800 parts of cold water, but is somewhat less soluble in hot water, so that when this clear lime water is boiled, it will deposit a portion of its lime.

The principal use of lime is for making mortar, and in this case sand is used, not only to prevent the cracking which would happen if a mere paste of lime and water were used, but also to unite chemically with a portion of the lime, a layer of true silicate of lime being formed round each grain of sand. The conversion of the lime into carbonate takes place with extreme slowness, and appears to play a secondary part in relation to the hardening process, as samples of mortar taken from the Great Pyramid in Egypt were found to contain free lime.

The presence in lime of certain foreign bodies, as clay, oxide of iron, silica, or manganese oxide, exercises a remarkable influence on the properties of mortar made with it, such mortar possessing, in a degree depending on many circumstances, the property of setting under water. Such a lime is ordinarily called hydraulic lime.

At Puzzuoli, in Italy, a remarkable volcanic product, called puzzolana, is found, this material consisting principally of silicates of calcium, aluminum, and sodium. When this puzzolana is intimately mixed with an ordinary or "fat" lime, hydraulic mortar or cement is obtained which possesses most valuable qualities, and has satisfactorily resisted the destructive tendencies of two thousand years.

The mineral known as trass, and which not only is found abundantly on the banks of the Rhine, but also occurs in Ireland, is an analogous substance, and it is largely used in some parts of Germany and in Holland for making hydraulic mortar. Finely powdered silica, glass, or lightly burned clay in a state of minute division, possesses similar properties; but in the present day hydraulic cements are mostly obtained either by the careful calcination of impure limestones, as found in nature, or by the use of artificial mixtures—say of chalk and clay—made up to the required composition.

Enormous quantities of the so-called Portland cement are now manufactured in this and other countries, by mixing chalk with river mud; and, after the mass has dried, burning until incipient vitrifaction sets in. The mass, being now finely ground, forms an admirable hydraulic mortar when mixed with water and sand. Before you are samples illustrating the manufacture of Portland cement, which have been supplied by Messrs. White Bros. and Messrs. Francis & Son. It is not necessary for me to enter into any detailed description of the Portland cement manufacture, as this would require a course of lectures by itself, and you can study it up for yourselves, by means of Mr. Reid's useful manual on this subject and also his work on concrete.

The cement ordinarily called "Roman," is made from the nodules of highly ferruginous and very impure limestone, known as septaria, which are found in the Thames Valley, and it sets with great rapidity. Messrs. Francis & Son manufacture a similar article from the medina earth, which sets more rapidly than the ordinary Roman cement. They were kind enough to send me a small cask as a sample. A part of this was put to a practical test, by being used to mend a leak in the roof of my house, and the remainder is before you. Mr. Barker is now mixing some with water, and you

* Four lectures delivered before the Society of Arts, London. Lecture I. in SUPPLEMENT, No. 327.

will have an opportunity of seeing for yourselves how rapidly and firmly it sets.

Little can now be said as regards concrete, for the reasons already given, but a few illustrations of the admirable materials obtained by incorporating Portland cement, a hard material such as small stones, and water, are before you. The specimens lent by Mr. Lascelles, of Bunhill Row, illustrate his ingenious and quickly executed system of building with slabs made of concrete, and the models on yonder side of the room show his method of mounting the slabs or blocks. A book of designs by Mr. Norman Shaw illustrates well the capabilities of Mr. Lascelles' system. One of these designs has been photographed as a lantern slide, and will be shown on the screen by Mr. Barker. It is surprising what a variety of things can be made of Portland cement concrete—even tables, chairs, and casks have been made successfully, but all are subject to the drawback of being rather heavy.

Here are some fine examples of artistic casting in Portland cement, which have been executed by Messrs. C. H. & T. Mabey. Mr. Lascelles has also sent samples of finely moulded window dressings and other decorative articles.

In connection with the subject of concrete, it is necessary to allude to the so-called patent Victoria stone, a material which seems likely to take a very high place among artificial stones. It consists in the main of a Portland cement concrete, the aggregate consisting of granite chips. When the material is set, it is soaked in a solution of sodium silicate, which hardens it so much that, as regards strength and durability, it stands almost as high as granite itself.

Some artificial stones made according to Ransome's system are on the table. In this case sand, or pure silica, is cemented together by a strong solution of sodium silicate, and the articles are next hardened by a bath of calcium chloride. These stones are of especial value to making grindstones, sharpening blocks, and filtering slabs of vessels; uses which are illustrated by samples on the side table. Messrs. Ransome & Co. also make use of the silicate of soda and chloride of calcium solutions for rendering soft brickwork or stonework impervious to damp; the liquids being applied alternately; and their value for this purpose is well illustrated by this brick, one-half of which has been treated. Although there is scarcely any difference as regards the appearance of the two halves, you see that water is readily absorbed by the untreated half, but not by the portion which has been rendered impervious by the solutions of Messrs. Ransome & Co.

The dephosphorizing properties of lime have been rendered available in obtaining compact masses of the refractory metal, iridium; the spongy metal being first fused with a moderate proportion of phosphorus, after which the comparatively fusible phosphide is heated in powdered lime, until all the phosphorus becomes removed.

As an indirect manure, lime possesses some value, decomposing silicates, disintegrating organic matter, and destroying insects. As an agent in various chemical industries, lime holds an important position; its uses in tanning, the preparation of the caustic alkalies, the liberation of ammonia, and other processes, being very considerable. With respect to its bearing on the iron industry, my remarks must be deferred until the utilization of the furnace slag is considered. Some kinds of glass, as for example the hard Bohemian variety, contain a considerable proportion of lime; and powdered lime is often used in packing delicate articles of steel which it is undesirable to oil. In this case it most effectually prevents rusting.

[From the American Medical Weekly.]

CEREAL FOODS.

HIGHLY IMPORTANT AND EXTENSIVELY ADVERTISED CEREAL FOODS UNDER THE MICROSCOPE.—THE GENUINE; THE SPURIOUS; THE WORTHLESS, AND THE FRAUDULENT.—THERAPEUTIC AS WELL AS DIETETIC FACTS OF GREAT VALUE TO PHYSICIANS AND THEIR PATIENTS.

By Ephraim Cutter, A.M., M.D., Harvard, and University of Pennsylvania.

Author of Boylston Prize Essay, 1857; Delegate from Mass. Med. Soc. to U. S. Pharmacopœia Convention, 1860; Hon. Mem. California and New Hampshire State Medical Societies; Associate Member Philosophical Society of Great Britain and of the Société de Microscopie Belgique; Principal Med. Dept. Am. Institute of Micrology; Author of "The Clinical Microscope," and "Introduction to the Use of the Microscope," and of many medical and scientific papers, etc., etc., etc.*

The great difference existing in the character and quality of cereal foods (wheat, corn, oats, rye, and barley), offered for sale, has attracted the attention of all close observers. Some of these advertised "foods" are perfect and genuine; some are defective and injurious; while many are worthless in composition, and even fraudulent in preparation.

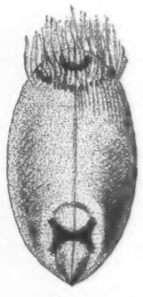

Fig. 1.

Fig. 2.

These demonstrable facts are highly important, of course, to physicians, who use such foods so largely and so well in the treatment of many diseases; but they are of equal importance to the members of every community: to mothers who, above all, are chiefly charged with the responsibility of the diet of their children, and especially of those undergoing the suffering and dangers of teething; to fathers who, however busily engaged, are deeply interested in the safety and comfort of their families; and to the millions who, suffering from indigestion and dyspepsia, seek anxiously for relief and cure by the use of foods best adapted for their condition. To all of these, the truth in regard to foods, as revealed by that unerring teacher, the microscope, must be vitally important and interesting.

Fig. 3.

Fully appreciating the great importance of having demonstrated, to the public, the unquestionable truth in regard to the exact value of cereal foods, showing which foods are genuine and which defective, Dr. E. S. Gaillard (of this city) the editor of *Gaillard's Medical Journal*, and of the *American Medical Weekly*, requested me to examine, microscopically, all of these foods, and to report the results for publication. This request was made in April, 1881, and the examinations described have been carefully made during the

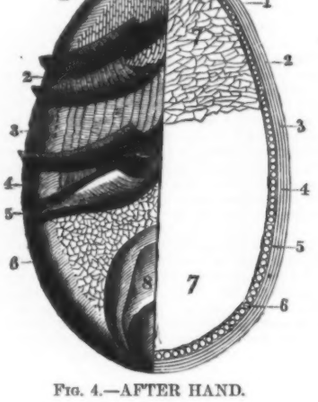

Fig. 4.—AFTER HAND.

eight months which have since elapsed. The examinations were made by me personally, and the microscopic drawings were made in my office and under my supervision, by Dr. A. T. Cuzner, of this city, one of the most competent, faithful, and skilled artists in this department of scientific art. The drawings prepared by him were photographed on the plates used in these illustrations by the Moss Photo-engraving Company, New York, and the results are all herewith presented.

lids and dyspeptics. It is alone capable of securing prolonged nutrition."

Starch is too well known to need description. "It is incapable alone of sustaining life."

If a grain of wheat, as a type of other cereals, be examined there will be found, first, the outer, middle, and inner coats, forming together the husk or bran; these coats are wholly destitute of nutritious properties. Next in order comes a layer of cells, or sacs, crowded together and lying in irregular shapes; these sacs averaging one six-hundred-and-seventy-fifth

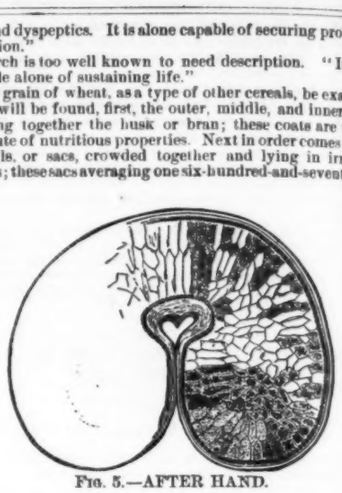

Fig. 5.—AFTER HAND.

of an inch in diameter, contain gluten, with a little oil and albumen. The gluten is in the form of small granules, one fifteen-hundredth of an inch in diameter, and when a sac is ruptured, these adhere to each other (are glued together) with great tenacity. Lastly, in the center of the grain, packed away in cells or sacs, is the starch, also in small granules. These sacs or cells are in the form of oval globules, and, when ruptured, as is done by boiling or cooking, the inside contents escape, forming a glutinous mass, in which, under the microscope, are seen the broken sac membranes in crescentic and irregular shapes.

These grains, with the coats and cells or sacs, are accurately given in Figures 1, 2, 3, 4, 5, and 6.

The reader has here a clear insight into the rationale and the reliability of the examination of cereals under the microscope.

The foods examined and described are as follows: 1, com-

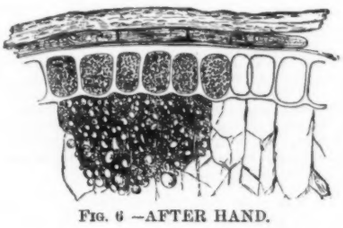

Fig. 6.—AFTER HAND.

mon flour; 2, imperial granum; 3, Ridge's food; 4, Horlick's food; 5, Mellin's food; 6, gluten flour; 7, Franklin Mills entire wheat flour; 8, Arlington wheat meal; 9, Crosby's food; 10, Blanchard's No. 1 gluten; 11, Blair's wheat food; 12, Nestle's milk food; 13, baby sop, No 1; 14, baby sop, No. 2; 15, Redmond's cerealine; 16, Anglo-Swiss milk food; 17, Durkee's glutena; 18, Farwell's gluten flour; 19, Victor's baby food; 20, Bermuda arrow root, from the plant; Taylor Brothers, London, pure Bermuda arrow root; 22, Minnesota surprise flour (new process); 23, trade dollar process flour; 24, Hubbell's prepared wheat; 25, mother's cereal milk substitute; 26, Hawley's Liebig's food; 27, papoma; 28, Gerber's food for infants and children; 29, Gerber's milk food; 30, cold blast flour, extra, New York Health Food Co.; 31, barley flour, extra, New York Health Food Co.; 32, buckwheat flour; 33, indian wheat flour; 34, Lost Nation wheat flour; 35, Corinna wheat flour; 36, St. Paul wheat flour; 37, Hazleton

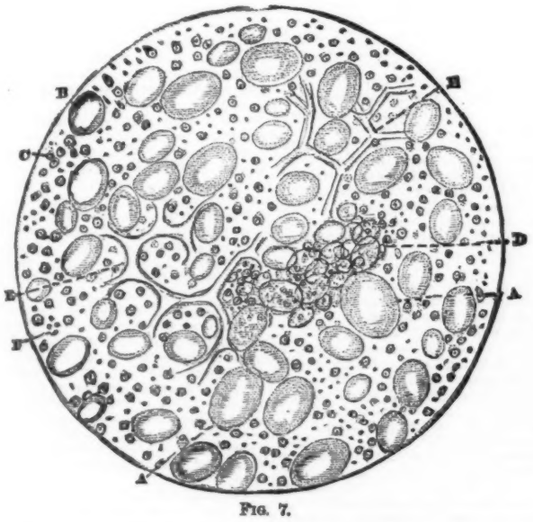

Fig. 7.

All cereal foods (wheat, oats, corn, rye, and barley) contain almost exclusively gluten and starch.

Gluten is the viscid, tenacious substance of dough, and in addition to its highly valuable nutritious property, is essential in all panification or bread making. Gluten, says Magendie, the immortal French physiologist, "by itself secures complete and prolonged nutrition." Pereira, the great authority, says "gluten is easy of digestion, and substances which contain it largely are readily digested even by invawheat flour; 38, Puritan wheat flour; 39, Patapsco wheat flour; 40, Underwood wheat flour; 41, fine granulated wheat flour; 42, cold blast whole wheat dark flour; 43, crude gluten flour; 44, white gluten flour.

Do these foods sustain their claims?

Figures 1, 2, and 3 represent a grain of wheat. Note the beard, the longitudinal groove, and the germ.

Fig. 4. This figure is from Horsford's report on bread at the Vienna Exposition. It represents a longitudinal section

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We are requested by Dr. E. S. Gaillard to state that Figures 4, 5, 6 and 8 were not prepared for his Journal, but are the original cuts used in the Horsford Report on Bread, at the Vienna Exposition; these cuts being kindly placed at his service by Mr. T. J. Hand, of this city, to whom the public is indebted for their execution. By an accidental omission, much regretted, these facts were not stated in the *American Medical Weekly*.

of a grain of wheat: 1, outer coat; 2, middle coat; 3, inner coat; 4, color coat; 5, gluten coat; 6, gluten cells; 7, parenchyma, or starch mass; 8, the germ.

Fig. 5. This figure represents a transverse section of a grain of wheat. Note the different coats: the envelope coats; the gluten coat (dotted), and the starch masses within

Fig. 6 Portion of a transverse section of a grain of wheat; shows empty and filled gluten cells; starch masses in the interior, with the tough, fibrous connective tissue. The reader should learn here to identify the large gluten cells, empty and filled, forming the third coat. The shape of these cells should be remembered, for it is upon the gluten in cereal foods that their chief value depends.

mass; C, starch bundles, apparently of maize; D, cooked mass of starch, which does not polarize light; E, starch grains; F, starch granules; G, small gluten granules. *The proprietors must add gluten cells, at least in the proportion found in wheat or maize, to bring their product up to the standard of wheat flour.*

Fig. 11. HORLICK'S FOOD, magnified 800 diameters. The starch that makes up the bulk of the food is changed into dextrine, or sugar, hence it is soluble. A, cooked, vegetable granular mass; B, hair of wheat; C, empty and filled gluten cells, found only after a long search through several specimens. The dark unsightly masses are portions of cooked material, that have no effect on polarized light.

flour. The circulars are travesties, and show an ignorance which, if it did not affect human life, would be ridiculous. *Where only seventy gluten cells are found in a flour claimed to be all gluten, comment is unnecessary.*

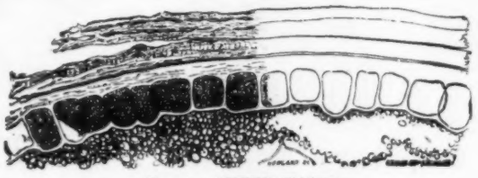

FIG. 8.—AFTER HAND.

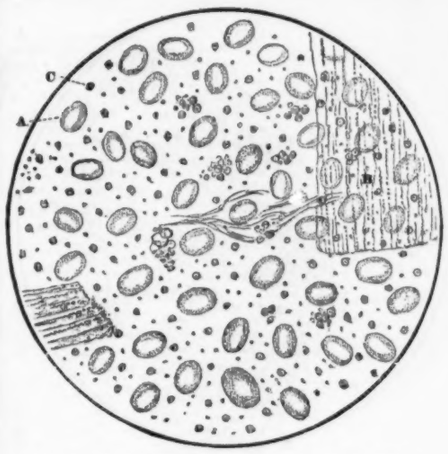

FIG. 13.—GLUTEN FLOUR.—N. Y. HEALTH FOOD CO.

Fig. 7. Common wheat flour, magnified 800 times.—A, giant starch cells; B, medium starch cells; C, starch granules, aleurone (or farina), and granular gluten from ruptured gluten cells; D, starch bundles and fibrous tissue; E, fibrous tissue. There are no gluten cells, these being ruptured, liberating the granules of gluten. *In making flour, three fourths of the gluten is removed, and the chief strength of the food is thus destroyed.*

Fig. 8. Transverse section of a scale of bran, magnified 150 diameters. This bran is removed to make flour white, and this removal is the cause of the loss of three-fourths of the gluten. Note the gluten cells, thickly packed away in the bran. The removal of the bran, it is thus demonstrated, is the removal of the gluten.

Fig. 9. THE IMPERIAL GRANUM FOOD.—This food is

Claims "to be a perfect food for infants." *It approaches common flour.*

Fig. 12. MELLIN'S FOOD.—Segment of covering of the wheat grain, A; B, empty gluten cells; C, hair of the beard of wheat; D, gluten cells of wheat; E, collection of many gluten cells, not of wheat (note difference in shape of these cells and those marked B and D). Gluten cells readily found. Claims to be the only substitute for mother's milk, and not farinaceous. It is not polarized by light, save in a few starch grains scattered here and there. Starch is changed into a soluble form, so as to readily enter the circulation, on its introduction into a defectively digesting alimentary canal. *This food stands high on the list. Should the proprietors put in the full proportion of gluten cells it would be faultless. Magnified 800 diameters.*

Fig. 15. FINE FLOUR OF THE ENTIRE WHEAT, manufactured by the Franklin Mills Co., Lockport, N. Y., magnified 800 diameters. The field is filled with gluten cells, A; B, hairs of wheat; C, gluten comb coat.

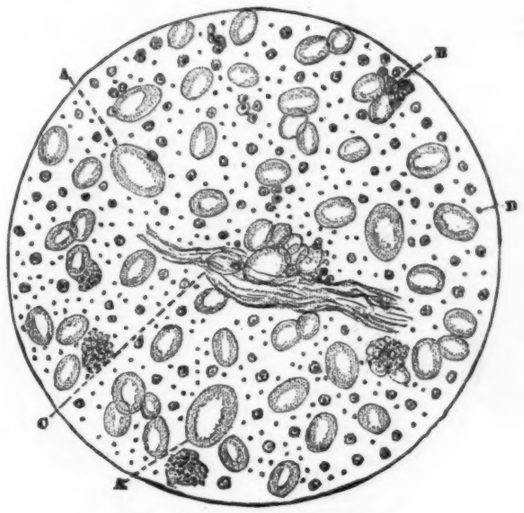

FIG. 9.—IMPERIAL GRANUM.

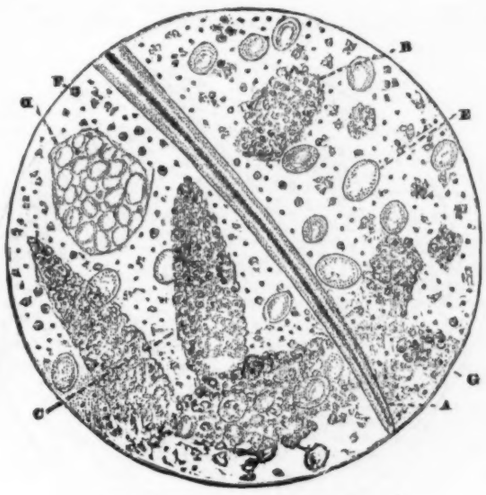

FIG. 10.—RIDGE'S FOOD.

represented to be gluten from white, winter, flint wheat; the starch, impurities, and soluble matter effectually excluded, the gluten only retained, etc. There are no gluten cells visible. Note the giant starch grains, A; B, granules of starch and aleurone; C, connective tissue; D, granular

Fig. 13. GLUTEN FLOUR, New York Health Food Co.—Claiming to be "almost no starch and all gluten." A, starch grains; B, fibrous tissue; C, starch granules. No gluten cells visible or to be found. *It cannot be distinguished from common flour.*

Fig. 16. THE SAME FLOUR.—A, gluten cells; B, starch bundle; C, connective tissue; E, aleurone and gluten granules; G, giant starch grains. *Repeated examinations prove this to be the best flour examined. So long as the makers maintain such a proportion of gluten cells, they confer a blessing on*

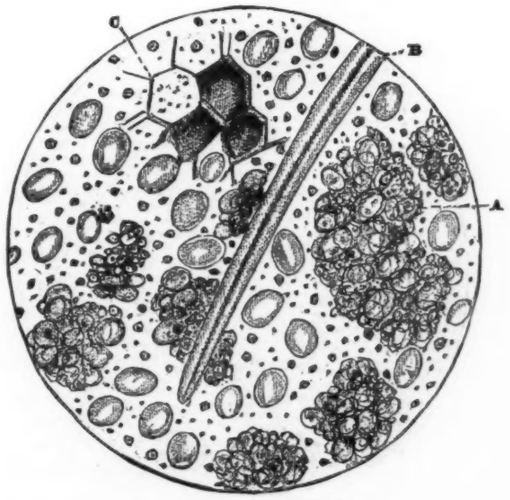

FIG. 11.—HORLICK'S FOOD.

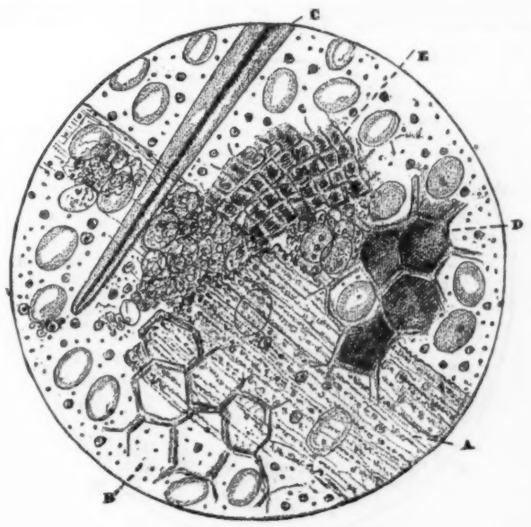

FIG. 12.—MELLIN'S FOOD

gluten. I have always failed to find gluten cells. *It ranks only with common flour.*

Fig. 10. RIDGE'S FOOD, magnified 800 times.—It is claimed to be "a perfect food for infants." It contains no gluten cells. Observe the beard of the wheat at A; B, wheat starch

Fig. 14. GLUTEN FLOUR.—Many specimens examined by myself and Dr. G. B. Harriman, of Boston, Mass. Masses of tegument and parenchyma, A; B, tegument; C, gluten cells—in repeated examinations about seventy were found; D, starch masses; E, connective tissue. This is a meal, and not a

mankind. It produces a light and spongy bread. It is a reliable infants' food.

Fig. 17. ARLINGTON WHEAT MEAL, magnified 800 diameters. A, tegument of wheat with gluten cells around and underneath; B, tegument, with no gluten cells, C, fibrous

tissue with contiguous starch cells and aleurone, and granular gluten in the interspaces. "Meal" is the product of a cereal ground coarsely, without bolting. Wheat thus ground is often called Graham flour, after Dr. Sylvester Graham, the noted vegetarian. A spurious Graham is wheat flour, mixed with bran. The Arlington is a pure Graham flour; rich in gluten and in all the elements of entire wheat.

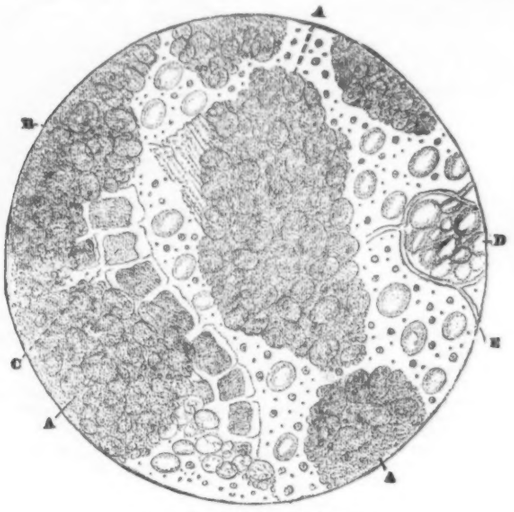

FIG. 14.—GLUTEN FLOUR.

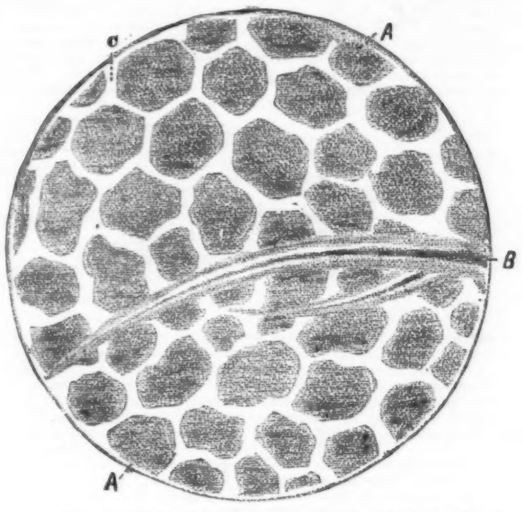

FIG. 15.—FRANKLIN MILLS ENTIRE WHEAT FLOUR.

Fig. 18. CROSBY'S BRAIN AND NERVE FOOD, magnified 800 times. Claims to be composed of vitalized phosphates from ox brain and wheat germ. A, large mass of starch, obscuring the underlying starch, so large in some specimens as to occupy the whole field; B, ill-defined dark granular mass resembling gluten cell, though such an opinion is not warranted; C, similar masses; E, a gluten cell, possibly; D, apparently cooked animal substance. There are no characteristic gluten cells, no nerve fiber, no axis cylinder fiber, no ganglion nor multipolar cell. The advertisement claims that the brain is that of the ox, but the label states that the brain is that of the fish. Label admits 730 parts of starch in 1,000; claims some gluten. If this exists, it is the granular gluten of common flour. There are 270 parts of so-called vitalized salts asserted to be in this food; that is, salts formed in connection with the organic substances named. If this be so, all the albuminoids in all the foods herein described are vitalized also. There is but little gluten if any in this food.

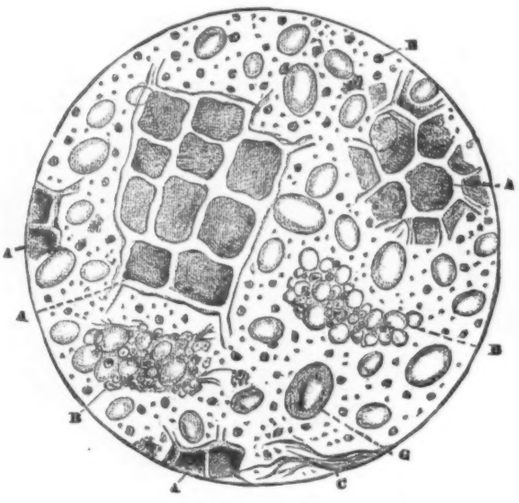

FIG. 16.—FRANKLIN MILLS ENTIRE WHEAT FLOUR.

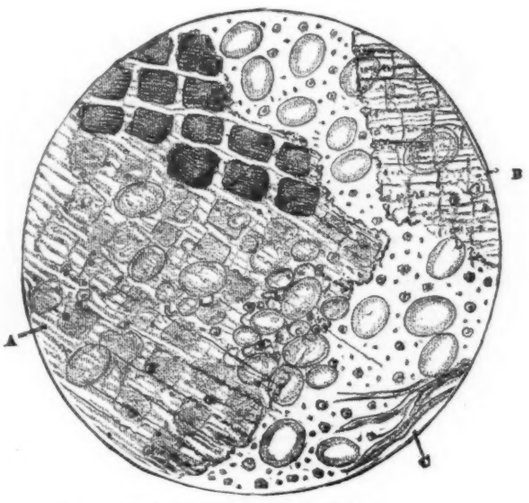

FIG. 17.—ARLINGTON WHEAT MEAL.

Fig. 19. BLANCHARD'S GLUTENA, magnified 800 diameters. Claims to contain 90 per cent. of gluten; starch only 10 per cent. A, large masses of starch, polarizes light beautifully, showing that the starch is not cooked or overheated; B, gluten cells. Gluten abundant; contains all the elements of wheat. *While there is gluten always found, this food contains 90 per cent. of starch, and only 10 of gluten—the reverse, exactly, of the claim made for the food.*

BLAIR'S WHEAT FOOD.—Well represented by Figure 9. *Abundance of free starch grains, giant, medium, and granular. No gluten cells.*

Fig. 20. NESTLE'S MILK FOOD; OR, LACTEOUS FARINA.—Magnified 800 diameters. A, masses of cooked starch; B, small granules of starch. Claims to be made of the best cow's milk. *It contains starch, and in the field there is an abundance of oil globules. There is milk in it and a quantity of starch, but no gluten cells.*

Fig. 21. ANGLO-SWISS MILK FOOD.—Magnified 800 times A, starch cooked; B, oil globules; some gluten cells. *It is a milk food, with some gluten and cooked starch.*

Fig. 22. Baby Sup. Nos. 1 and 2, magnified 800 times. A, large masses of oat gluten cells—notice how they differ in shape from the wheat gluten cells; B, starch bundles; C, granular starch. The three grades are prepared for infants of different ages: No. 1 for the youngest. This food is a malted preparation. Contains all the elements of the oat; an abundance of gluten. Starch grains much smaller than those of the wheat, and the gluten cells of characteristic shape. This food is made of unhulled oats malted and crushed. See Figures 23 and 24. *Sustains its modest claims.*

Figures 23 A—23 B. The oat as found in examinations of Baby Sup.

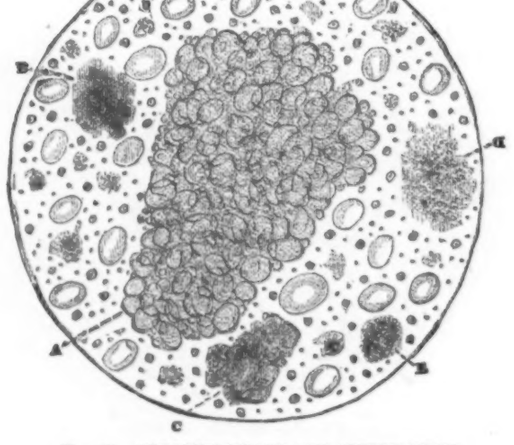

FIG. 18.—CROSBY'S BRAIN AND NERVE FOOD

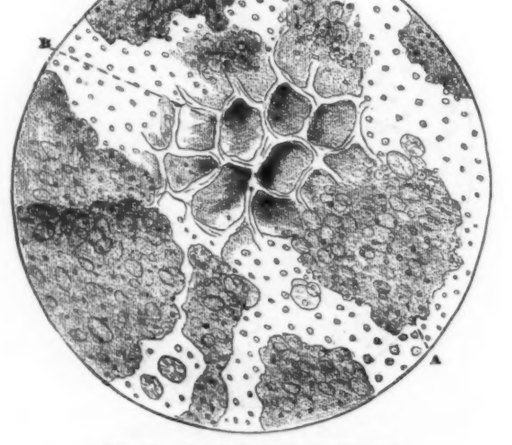

FIG. 19.—BLANCHARD'S GLUTENA.

Fig. 24. REDMOND'S CEREALINE, magnified 800 times. Polarizes light partially only. Made up of wheat starch grains. Bundles few. After many examinations a portion of tegument was found, containing all coats, and 50 gluten cells. *Claim of being economical (50 cents a pound), superiority to all other cereals, etc., not sustained.*

up into weird, irregular crescentic shapes, due to the mechanical crushing, after cooking. *It is like cracker and biscuit ground up.*

Fig. 27. BERMUDA ARROW ROOT STARCH, from the pure and genuine Bermuda arrow root, magnified 800 times.

Fig. 28. "The Pure Bermuda Arrow Root of Taylor Brothers." *Potato starch cells are here commingled with a few of arrow root; the adulteration is beautifully exposed, and the claim of purity is comical indeed. The manufacturers should examine these arrow root cells and their starch product under the microscope!*

mechanism, construction, and chemical elements of the cereals they describe and sell. Their language is not only unwarranted by scientific truth, but is absurd. They speak of "the chemical salts being separated by mechanical means," etc., etc.

Their preparation, nevertheless, is a good one, and contains more of the elements of wheat than was anticipated. It contains gluten cells, bundles of wheat starch, barley starch, and gluten granules.

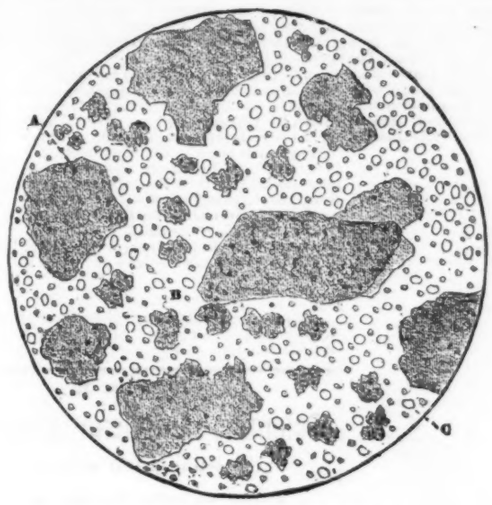

FIG. 20.—NESTLE'S MILK FOOD

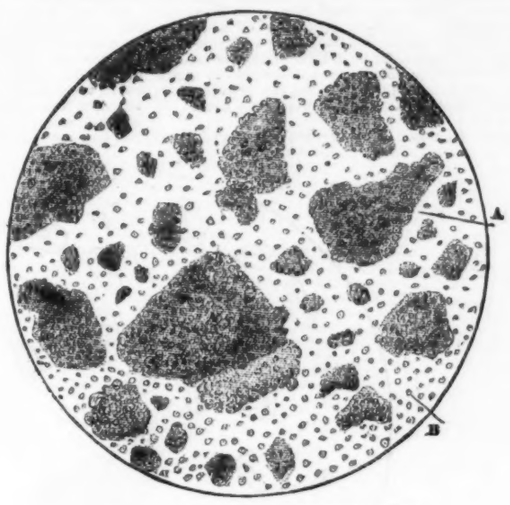

FIG. 21.—ANGLO-SWISS MILK FOOD.

Fig. 25 DURKEE'S GLUTENA, magnified 800 times. A, masses of parenchyma of wheat grain, starch removed; here and there a strip of gluten cells outside. Beautiful starch grains and granular starch. *Figure 7 represents this food when crushed. Gluten cells not detected.*

HAWLEY'S LIEBIG'S FOOD.—Wheat gluten cells, barley gluten cells, barley tegument, wheat starch, cooked granular masses, not polarizing light. Well malted. *A good food, and its claims are sustained.*

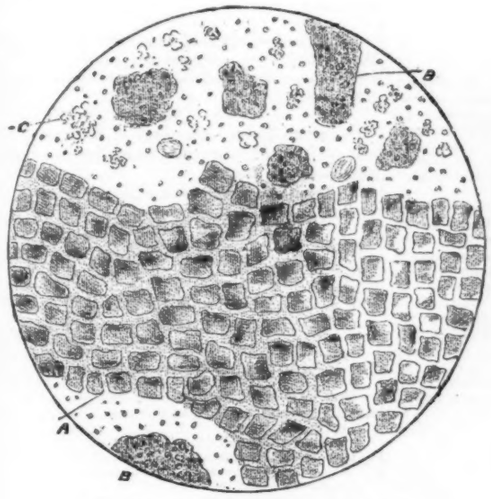

FIG. 22.—BABY SUP—NOS. 1 AND 2.

FIG. 23a.

FIG. 23b.

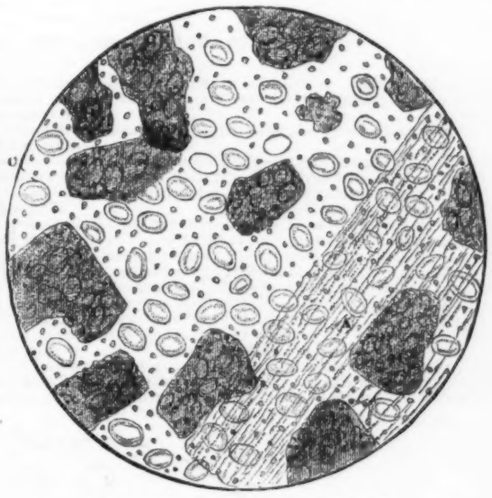

FIG. 24.—REDMOND'S CEREALINE.

FARWELL'S GLUTEN FLOUR.—Claims to be "gluten left behind after the starch is blown out." It required a long search to find any gluten cells. It is similar to the food last named, and Figure 25 is a good representation of it.

MINNESOTA SURPRISE FLOUR.—This contains all the elements of the wheat, save *the gluten cells.* There is more granular gluten than is found in ordinary flour.

TRADE DOLLAR NEW PROCESS FLOUR, like the last.

THE FOLLOWING ADVERTISED FOOD STUFFS CONTAIN NO GLUTEN: Cold blast flour, N. Y. Food Co.; barley flour,

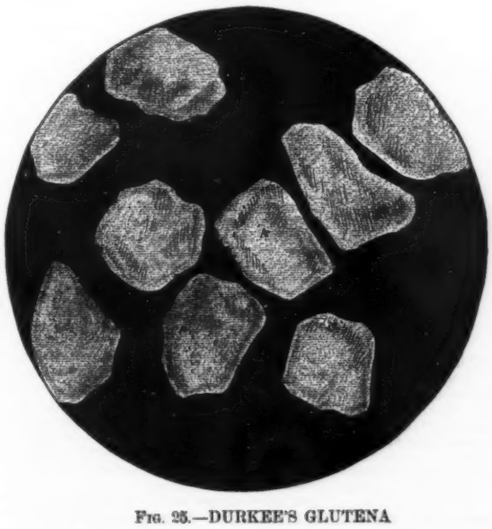

FIG. 25.—DURKEE'S GLUTENA

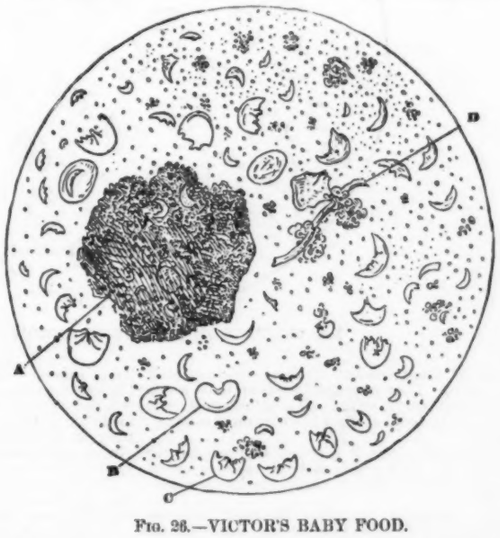

FIG. 26.—VICTOR'S BABY FOOD.

Fig. 26. VICTOR'S BABY FOOD, magnified 800 times. Claims "a close resemblance to mother's milk." A, large mass of cooked starch; B, starch grains deformed by cooking; C, broken starch cell; D, fibrous tissue, one gluten cell, occasional fat globules. Figure shows starch grains broken

HUBBELL'S PREPARED WHEAT.—Starch cooked, but not enough to prevent polarization of light; starch-bundles and alenrone. A few gluten cells. *Not up to its claim.*

MOTHER'S CEREAL MILK SUBSTITUTE.—The claim made shows that the manufacturers are profoundly ignorant of the

do.; buckwheat flour, do.; India wheat flour; Lost Nation wheat flour; common Minnesota flour; Hazleton flour; Puritan flour; Patapsco flour; Underwood flour; fine granulated wheat flour (30 gluten cells); Gerber's food for infants and children (seems to be crackers ground),

and resembles Figure 20. Gerber's milk food is like Nestle's; no gluten cells.

The medical profession should create an accurate public sentiment in regard to cereal foods. All of those which contain no gluten lack the chief nutritive element of the grain. The microscope is an infallible detecter of such fraudulent claims in regard to cereal foods. The proportion of starch to gluten is easily demonstrated, and the absence of gluten is easily exposed. In all white breads there is no bran; and if the bran is excluded, such flour is deprived of its gluten, the gluten being deposited in the bran. See Figures 4, 5, 6, and 8. The chemist's balance and the compound microscope teach the truth, and if the truth is not told in regard to advertised cereal foods the imposition can always be detected. These simple facts and absolute facts should be universally known.

SUPPLEMENT—KEASBEY & MATTISON'S INFANTS' FOOD clusively nitrogenized diet, repair of tissue waste cannot be effected in those who consume only the non-nitrogenized foods. To be more explicit and comprehensive, it may safely be asserted that man can live and maintain a vigorous existence, on an exclusively nitrogenized diet; while on a diet of non-nitrogenized food exclusively, he is unable to maintain life, such a diet being fatal, if persistently and exclusively adopted.

It is well known, from actual experiment, that an animal may be fed to such an extent on fatty foods, that the hairs on the body are actually infiltrated with oil, and yet, in a well known period of time, the animal is sure to die. The result with a saccharine diet is exactly similar; while with a starch diet, though the fatal result is somewhat longer postponed, it is none the less sure to occur. A prominent and well known physician in this city, who undertook to ascertain how long he could maintain life without serious suffer-

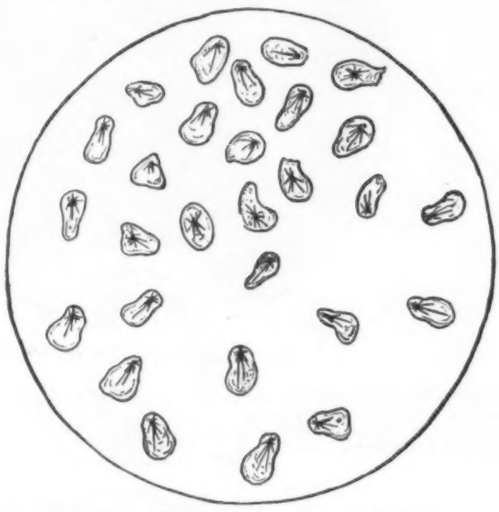

FIG. 27.—GENUINE BERMUDA ARROW ROOT.

contains no gluten cells. It consists of grape sugar and dextrine (converted starch), and is claimed to contain alkaline phosphates.

SAVORY & MOORE'S FOOD.—Appears the same as common flour.

MEAD'S HULLED WHEAT FLOUR.—First, second, and third coats generally removed; fourth, fifth, and sixth coats usually found—a coarse flour or meal; does not polarize light well. Preparation good and deserves support.

SUMMARY BY THE EDITOR.—Having disposed of the microscopic analysis of the cereal foods, in detail, it is necessary to add a few important facts, in order that each reader may be enabled to form clear and intelligible conclusions.

In taking a comprehensive view of all the foods known to civilized man, it may be positively stated that such foods can be classified into two large groups; and there are no known foods which do not properly belong to one or the other of these two great classes. These groups are the nitrogenized and the non-nitrogenized foods; or the foods which contain nitrogen as an element of their composition, and those in which no nitrogen is to be found. The non-nitrogenized group of foods consists of those which contain starch, sugar, or fat. The nitrogenized foods are those which do not contain starch, sugar, or fat. This last group is made up of the immense varieties of food in which there is no fat, starch, or sugar.

Having learned these facts, it is proper to determine the relative value of the foods which make up these two great groups, viz., the relative value of nitrogenized and non-nitrogenized foods.

The simplest manner of presenting this most important subject is to assert, as a well established fact, that while the non-nitrogenized foods (the starchy, saccharine, and fatty foods) are almost solely effective and solely intended for the purpose of maintaining animal temperature, the nitrogenized foods are consumed in repairing the natural wear and tear of all the true tissues of the body. While animal temperature, however, may be maintained in those who subsist on an exing on a diet of gum and starch, has, though this diet was soon abandoned, never recovered from the effects of his rash experiment. While twenty-five years have elapsed since the endurance of his self-imposed ordeal, his heart to-day beats thirty per cent. faster than it did previous to his experiment. No facts in science then are better established than those in regard to the comparative and relative values of different kinds of food.

If these facts be applied to the study of the cereal foods, it is only necessary to remember that the gluten of such foods is their nitrogenized element, the element on which depends their life-sustaining value, and that this element is, in the white and foolishly fashionable flour, almost entirely removed; while the starch, the inferior element, is left behind, and constitutes almost entirely the bulk and inferior nutriment of such flours. To use flour from which the gluten (in the bran) has been removed is almost criminal; that it is foolish and needless needs now no further demonstration.

In sickness, and in the sickness of infants especially, starch is highly injurious, while gluten is life-giving and restora-

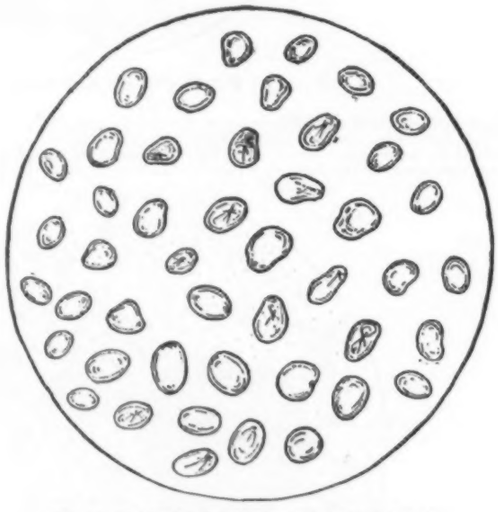

FIG. 28.—TAYLOR BROTHERS' ARROW ROOT.

tive. Infants' foods should be rich in gluten, and contain the least possible proportion of starch. Those manufacturers and sellers of such foods who, while claiming to offer a food rich in gluten and free from starch, offer, on the contrary, an article consisting chiefly of starch and devoid of gluten, are criminal in their fraud, and deserve the most unsparing condemnation.

The beautiful microscopic pictures in this article are therefore absolutely invaluable guides to all who seek to understand this most vital subject.

Of course, it will be said by all parties who represent foods not found to be as they are publicly represented to be, that these foods do not contain gluten. Their claim is not denied; but if the proportion of gluten in such foods be far less than it is in ordinary wheat flour, is it not better for the patient to use ordinary flour than to buy cereal foods far inferior to flour in dietetic and therapeutic value, while financially their cost is very much greater, is indeed enormous! And if these cereal foods contain (as so many of them do) far less gluten than is to be found in ordinary wheat flour, is not the claim made for them not only untrue, but fraudulent in character?

With the text and illustrations here submitted, every reader can easily detect the defective or worthless or fraudulent foods offered for sale; and as the difference in these foods represents frequently the difference of life or death in those needing them, the practical and scientific character of this paper is too evident to need demonstration or description.

It is almost criminal that such great questions, affecting the health and therefore the happiness and wealth of a nation, should be left to the ignorance of the miller and the baker; to the foolish customs of society; to the equally foolish test of the mere appearance of bread; and to the fashionable restaurants and hotels. Manufacturers of food for the sick, and, above all, for infants, should be held to the strictest accountability. It is the highest duty of the physician to learn the facts in regard to cereal foods, and to use such invaluable information for the benefit not only of the sick, but of the whole community.

This article will be followed, during the year, by equally practical and valuable articles on "what we eat and drink."

E. S. G.

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